MODULARISATION AND PRE-ASSEMBLY PAPER #4
RISK PROFILES

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INTRODUCTION AND OVERVIEW

This paper has been compiled to provide the reader with a more comprehensive discussion on the risk profiles of a modular or pre-assembled project delivery than was possible in the paper by the author, Modularisation and Pre-Assembly Paper #001 – Underpinning Economic Development Parameters. The discussions and topics broached in this paper are not intended to be prescriptive or encompassing for all project circumstances or scenarios. To the contrary, this paper is intended to frame the readers focus onto the areas of their project development that have an applicable risk specific to a modular or pre-assembly delivery method. Project owners and delivery resources should find this paper equally valuable in the identification of relevant risks but the paper should not be construed as a comprehensive risk analysis that is applicable in totality to any specific project. The discussion topics are the result of authors exposure and insights into a range of projects delivered by a modular or pre-assembly methodology. The topics addressed will be introduced in the following grouping and sequence.

1. Primary Risk Profiles;
2. General Risk Profiles;
3. Project Management and Control Risk Profiles;
4. Modularisation and Pre-Assembly Supply Chain Risk Profiles;
5. Concluding Comments.

These key areas will be discussed in the context of project delivery in general. Modularisation and pre-assembly project delivery will be viewed from the supply chain perspective to eliminate the tendency to dwell on the scale and visual aspects of the project delivery method. As with all project delivery methods, a modular or pre-assembly delivered project has potentially beneficial, and adverse risk profiles associated with each project phase and the execution activities within each phase.

PRIMARY RISK PROFILES

Importing Hours to the Construction Site

It is appropriate to begin the discussion of risk by introducing and defining the primary risk to the success of a modular or pre-assembled project delivery. The most destructive and irreversibly damaging occurrence in a modular or pre-assembly delivered project is the importation of construction hours to the site location that were allocated to a location of lower cost and higher efficiency.

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It must be clearly understood that this situation will destroy the beneficial economic and schedule related advantages of a modular or pre-assembly delivery strategy with predictable certainty. Each project has a finite differential in economic benefit between on site, "stick built" and off site modular or pre-assembly. Once the hours allocated to an off site location and cost centre are imported to site, the damage to the underpinning module or pre-assembly economics is irreversible, the value of the strategy is lost.

Once the decision to progress a project via a modular or pre-assembly strategy is validated by economics and cemented as the execution strategy by the project owners and management, uncompromising vigilance must be maintained and focused on maximizing the value train of the modularisation and pre-assembly strategy. Failure by the project delivery team to maintain the required level of focus on module and pre-assembly economics through maximized value adding in off site and offshore locations will result in the generation of an adverse financial risk profile for the project. Schedule control is also a project parameter that suffers greatly from the importation of off site or offshore allocated construction hours to site. Site labour and associated infrastructure

support should be balanced for the modular or pre-assembly delivery methodology, any increase in site resource requirements directly influences the practical ability to deploy and accommodate resources on site. This situation invariably leads to an extended delivery schedule. There is also a detrimental effect on maximized safety benefits through construction hour importation to site, and by extension, consequential negative flow-on effects to other key areas such as quality, which are generally enhanced by modular or pre-assembly delivery methodology.

Safety Enhancements

The preceding discussion provides a strong platform to discuss safety enhancements for overall project delivery via a modular or pre-assembly delivery strategy. Although there are other areas of the delivery methodology that provide substantial benefits, the author believes that safety improvements in construction is by far the most converted and valuable prize.

Safety enhancements from a modular or pre-assembly delivery strategy can fundamentally improve the risk profile of the project construction phase on site. The key factors related to site safety enhancement include the following;

Insight Into Risk Exposure for Direct & Indirect Construction Hours

Construction hours are the core currency of modular and pre-assembly economics. Direct construction hours are always accompanied by Indirect construction hours.

Total Site Hours = Direct Hours + Indirect Hours

This well know and simple equation conceals a very real, and sometimes unforeseen risk exposure potential for a project. Hours for site construction are generally developed on a materials of construction basis, linked to construction commodities and their relevant trade or craft installation time. This is widely known as the “Direct Hours”. These Direct Hours are established with the applicable site productivity considerations and historical data from other projects. This direct hour has supporting hours applicable to supervision, semi skilled and unskilled support, plus hours for general project support personnel. These hours are widely known as the “Indirect Hours”. Many estimates are developed and established from a Direct Hour cost basis, without specific allocation of Indirect Costs, but not the associated Indirect Hours. The following equation will be familiar to many readers in respect to site based labour.

Total Site Cost = Direct Cost + Indirect Cost

In the development of project cost estimates, the Indirect Cost component is often dealt with as a multiplying factor. This factor can typically range from 1.8 to 2.2 dependent on the specific project requirements. This approach to estimating is widely used in industry with solid historical precedence.

Schedule and cost increases experienced by many large projects of recent times may have some links to this cost source . Project control systems are strongly linked to Direct Cost and Direct Hours. Given that project control systems are generally robust, unexpected project cost overruns must then be the result of an area that is ill defined or inadequately measured. This enlightenment as to the potential sensitivities on project outcomes as a derivative of total site hours can potentially allow a project to establish its basis of economics and estimation on a platform of both Direct and Indirect cost and associated hours.

The reader may rightly ask, if the cost is accounted for, then is not the associated risk profile identifiable and quantifiable? The short answer is, probably not. Formulating an estimate basis on cost alone does not fully identify or account for the associated total hours. This leaves the associated risk profile unclear and the sensitivity of the project economics and practical strategic configurations unknown. In essence, the risk associated with direct site construction hour variation or creep is obscured by the belief that the Indirect Cost factor or multiplier applied to Direct Costs covers the issue of indirect construction hours. In some cases this may hold true. However, a strong understanding of the make up of Indirect Costs and their associated hours must be central to the project owner or manager progressing on this basis. Any hour on site must at some point represent an individual. All site personnel require accommodation, supporting infrastructure, transportation, site condition such as rotation R&R, supervision and project support such as safety management etc.

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1. Reduction of overall construction resource numbers on site. Less personnel on site statistically infers less likelihood of incident or accident;

2. Safe permanent access to all levels of construction is provided quickly with a modular or pre-assembly delivery project delivery;

3. Temporary scaffolding and rigging configurations required within a module or pre-assembly can be installed prior to site delivery reducing the interface of workplace discipline interaction and the handling of loose components on site;

4. Requirements for crews to remove floor and gratings to progress construction is substantially reduced eliminating a well documented and extremely hazardous potential from the site work environments;

5. Requirements for construction crews to concurrently work above and below each other in incomplete structures are significantly diminished removing a substantial and extremely hazardous falling object risk.

While there are other safety associated benefits from a modular or pre-assembly delivery specific to each project, these key areas hold a high degree of value to a project and generic applicability to all projects. As a key component of continuous project safety improvement opportunity, modularisation and pre-assembly holds enormous ongoing potential to generally improve site based construction safety standards!

GENERAL RISK PROFILES

The discussion of general risk profiles is associated strongly with the corporate focus of the project owner. The discussion will not extends to the detailed execution consideration applicable to specific projects but will retain a high level focus. The key points addressed are of a strategic nature and in many cases directly underpin the viability of a project from a corporate perspective. A selection of key topics will be addressed in the following sequence;

1. Financial Risk Profile;

2. Cost Risk Profile;

3. Schedule Risk Profile;

4. Commercial Risk Profile.

Financial Risk Profile

In the context of this paper, financial risk profiles are those risks associated with the following items;

1. Foreign Exchange;

2. Escalation;

3. Duty and Taxes.

In respect to foreign exchange, a modular or pre-assembly delivered project in general will have multiple facets of exposure. These facets of project exposure extend through the procurement, fabrication and assembly phases of the project.

"It is possible to identify key vendors, suppliers and fabricators early in a projects development and advise them of the preferred commercial currency. This enables the project to manage the risk profiles associated with foreign exchange fluctuation by securing hedged parcels of the nominated currencies within the project owners corporate finance model."

The ability of the project to maintain a consistently quantifiable risk profile in this regard is to define the source locations for the key project activities most affected by foreign exchange variations and secure hedging amounts in the source location currencies.

It is not realistic to expect that key procurement and fabrication costs for offshore sourced materials, equipment and completed modules or pre-assemblies can be fully defined early in the project. However, it is possible to identify key vendors, suppliers and fabricators early in a projects development and advise them of the preferred commercial currency. This enables the project to manage the risk profiles associated with foreign exchange fluctuation by securing hedged parcels of the nominated currencies within the project owners corporate finance model.

The link between this key commercial strategy and the final exposure of the project to foreign exchange fluctuation is a critical point of note. The requirement is equally applicable to large and small projects. The ability to remove the risk of unknown impact of foreign exchange fluctuation before it falls onto the daily radar of the project during the execution phase is of tremendous value

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to the project owner and should not be overlooked as a key project owner's execution phase risk mitigation strategy. While this strategy does not eliminate all the associated risk, it provides a platform of stable progress during project execution.

Escalation exposure in a project can come from a number of project sectors, escalation of material cost, supporting services cost or labour cost. The risk profiles for services and labour related escalation cost will be discussed latter in the paper. With respect to material cost escalation there are significant potential risks to the project. Some measure of risk mitigation is possible for a project against escalation exposure and can be obtained by forward booking manufacturing or production runs with an agreed quantity range. There is also an opportunity for projects to specify design standardizations to comply with general supplier and vendor catalogue specification. Items such as steel sections, electric cable, general pipe, electric motors, pumps and general valves etc can be forward purchased in blocks. The key aspect of standardizing and then forward purchase of these standard catalogue items is that if there is a major move in base commodity prices for any of the given items, the project holds the required quantities at the start of the project execution. This position holds two key advantages for the associated risk profile;

1. It ensures that the project economics is not impacted by commodity price escalation during the project execution and allows the project managers to focus on project delivery and not commercial haggling and entanglement;

2. In the worst case, such as a project slow down or stoppage, the project holds readily marketable stock with high resale potential. Standard catalogue specification goods are more readily absorbed by the market and the original suppliers and vendors than special order items. In essence, this strategy allows the project to hold a potential asset rather than a higher risk custom manufactured item.

The final topic of this section will address the issue of duty and taxes in relation to a modular or pre-assembly delivered project. Duty and taxes by nature do not fluctuate greatly during the term of a project execution. However, they are often overlooked and poorly understood and researched prior to project execution. This common scenario often places projects in a situation where forecasted offshore fabrication and assembly costs are under estimated or completely omitted with the resulting search for funding during project execution. This potential exposure can come from both the offshore source country and the country to which the goods are imported. This risk is easily mitigated by early research into the full supply chain requirements of project execution by stepping through the export and importation process of the dispatching and receiving country and identifying the local and offshore customs and duty laws, processes and fees.

The cost associated with these tax and duty requirements can be a considerable burden during execution if they are not understood and accounted for in the general strategic development and economic evaluation of the project.

"The key aspect of the risk profile associated with the encompassing cost of a modular or pre-assembly delivered project is the sensitivity to changes in the execution of the base strategy. For instance, the sensitivity of moving construction hours to site from low cost, high productivity centres off site or offshore can cripple a projects economic viability base."

Cost Risk Profile

The discussion of this topic has been broached in another paper by the author; Modularisation and Pre-Assembly Paper #1 – Underpinning Economic Development Parameters. The reader is referred to this paper for more discussion.

The key aspect of the risk profile associated with the encompassing cost of a modular or pre-assembly delivered project is the sensitivity to changes in the execution of the base strategy. For instance, the sensitivity of moving construction hours to site from low cost, high productivity centres off site or offshore can cripple a projects economic viability base. If this same scenario is applied to a situation where the overall projected construction hours for the project have increased, then the project can face order of magnitude cost increases due to the addition construction hour importation.

As a general guide, the following key items should be paramount considerations, with consistent and diligently pursuit and implementation during project execution;

1. Eliminate the requirement and potential for the importation of construction hours to the site location, refuse to ship incomplete pre-assemblies or modules;

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2. Maximise the concentration of construction hours in low cost, high productivity and quality capable locations onshore or offshore;

3. Maximise the totality of possible fabrication and pre-assembly into key fabrication and assembly locations such that oversize shipping can be fully utilized to carry as much bulk freight as possible on common voyages transporting modules or pre-assemblies to site.

These key points are universally applicable to ensure that the risk profile of a modular or pre-assembly delivered project remains robustly positive.

However, situations out of the control or influence of the immediate project management sphere will always occur. The management team must be fully cognoscente of the ramification and cost of importing construction hours to site and demurrage of vessels delivering modules or pre-assemblies. In order for managers to make informed judgment decisions, a clear understanding of the overall consequences of construction hour importation versus oversize vessel demurrage cost must be communicated and continually reinforced throughout the project delivery team. Demurrage cost will seldom outweigh the total impact of importing construction hours to site. To ensure the project risk profile of a project execution phase is not detrimentally unbalanced, any circumstance requiring the importation of construction hours to site must be authorised and accompanied by a senior level change order authority and approval system.

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Schedule Risk Profile

Schedules developed within the parameters required for a modular or pre-assembly delivered project require a different focus on critical path activities than traditionally understood "stick built" project deliveries. Modular and pre-assembly delivery solutions by character offer a project owner the ability to concurrently open multiple work fronts simultaneously, progress them concurrently and realize an associated schedule advantage over a sequential "stick build" delivery approach. While this prize has highly beneficial implications for project completion and subsequent speed to market, there are associated risk considerations.

In order to achieve multiple, active work fronts that are efficiently contributing to project value, the corresponding engineering and commercial platforms must be established in advance and sustained through project execution. The project execution experience and studies undertaken by many project owners and project delivery resources clearly indicate the early stage pressure on both engineering and commercial resources, particularly procurement resources, to have substantial purchase orders and scope definition in place concurrently for all disciplines. This is in stark contrast with "stick build" delivery methods where civil disciplines are followed by other disciplines in the construction phase and there is some schedule float at the back nd of the project delivery phase.

Without a strong understanding of this fundamental schedule related issue, it may mistakenly be considered that a higher level of appropriate resources for engineering and commercial will suffice to achieve the associated productivities to support the concurrent construction activities. In fact, the required preparation for the concurrent multiple construction work fronts must be developed to a substantial degree in pre execution phases of a project. This paradigm shift from the traditional "stick build" project development process is considerably different for a successful modular or pre-assembly delivered project. The greatest potential detriment to a schedule orientated risk profile for a modular or pre-assembly delivered project is to assume that key planning and supporting engineering and procurement activities can be completed in the execution phase of a modular or pre-assembly delivered project. In general, the first six months supporting engineering and commercial support work in a traditional "stick build" delivery should be completed and ready to implement on day one of the modular or pre-assembly delivered project.

Commercial Risk Profile

As discussed in the preceding paragraphs, the commercial aspects of a modular or pre-assembly delivered project are required much earlier than in traditional "stick build" project execution. To support this requirement, it is necessary to develop a depth of commercial preparation to a point of finality such that initial and near term execution work is ready to execute commercially at the commencement of the project execution phase.

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This underpinning requirement introduces a risk potential to the project that must be addressed through commercial strategies for services contracts and procurement purchase orders that allow for variation in quantity and definition but minimise the risks associated with uncontrolled variations claims. An option to allow progression of commercial preparedness to match the developing engineering specification detail must be employs to allow these two key requirements to be developed in close parallel. The most effective method of containing the risk profile for the commercial aspects of a modular or pre-assembly delivered project is to develop the commercial packages on the basis of unit cost applicable to bracketed quantity packages.

This fundamental commercial strategy will allow commercial packages for both procurement and contracted services to be developed that are linked to the control estimates which should be developed in a similar manner as outlines in other paper by the author. This strategy constrains the risk associated with the commercial development to the definition of associated project quantities which are revised and confirmed during feasibility phases of the project. As such, the definition of the detail required by the project execution phase will be available at the commencement of the execution phase. While each project is different, these basic approaches of linking estimate development on a unit rate basis and modelling the commercial strategies to the same base development process. The project risk profile is then constrained to the definition and management of the scope quantities.

PROJECT MANAGEMENT AND CONTROL RISK PROFILES

There a key areas of a module or pre-assembly delivery strategy that are uniquely linked to this type of execution strategy. The key areas that this paper will discuss are as follows;

1. Quality Management of Offshore Facilities;
2. HR, IR and Commercial Community Considerations;
3. Environmental Considerations.

Quality Management of Offshore Facilities

Consistent quality is a key requirement for all project delivery methods but more poignantly necessary in a modular or pre-assembly delivery strategy. This requirement cannot be stressed to heavily. Poor quality in the areas of dimensional tolerance and fit up alignment of assemblies and components completed in off site facilities will most certainly drive the importation of unspecified construction hours to the site location. This is an extremely detrimental potential for the project.

Quality in any project delivery models is a fundamental management focus, a modular or pre-assembly delivered project is no different. In fact an increase in focus on quality matters is well placed given the potential downside implications of poor quality management. As a basic rule, the same resource allocation and focus on quality must be provided and sustained in a modular or pre-assembly delivered project as in a "stick build" project. The only general difference is the location of the required quality resources. Quality resources must be deployed at the point of fabrication and assembly and all upstream procurement sources. This is a key risk mitigation for quality related matters for a modular or pre-assembly delivered project.

"To maximise the positive risk profile for a modular or pre-assembly project, the focus on off site and offshore fabrication should be quality control on the ground rather than quality assurance systems. Specifically in the case of offshore facilities, a policy of "show me, don't tell me" should prevail."

To maximise the positive risk profile for a modular or pre-assembly project, the focus on off site and offshore fabrication should be quality control on the ground rather than quality assurance systems. Specifically in the case of offshore facilities, a policy of "show me, don't tell me" should prevail. Consistent focus on visually confirmed quality control rather than quality assurance systems is the fundamental key to success in quality.

As a strongly beneficial and functionally supporting strategy for increased quality control aspects of off site and offshore fabrication and assembly it is highly desirable to have the key site construction superintendents present in the facilities in the capacity of quality control wardens. The presence of the key superintendents in the facilities during the fabrication and assembly process generates a focused environment for quality control for the facility and ownership of the finished

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product by the final site installation owner.

HR, IR and Commercial Community Considerations

The human resources sectors of today often struggle to find the level of appropriate skills required for specialised site based construction work. While the importation of offshore labour is possible, it is extremely time consuming and in Australia it is becoming increasingly onerous from a cost and ongoing management perspective. The most effective method of securing the required skill in large quantities is to maximise the construction hours in offsite and offshore construction locations.

"The balance between local, national and internationally source fabrication and assembly also needs to be considered to ensure that local commercial communities remain supportive of the project but the balance of local focus does not tip the balance between project progression or postponement."

By keeping the balance of construction hours in the proportions that both the site and off site resources can accommodate will provide the project with the best opportunity to achieve high productivity while maintaining high safety and quality standards on site. Industrial relation areas are also eased by ensuring that achievable productivities expectations are applied to site construction such that the requirement for specialised labour on site is scheduled at levels where locally or nationally sourced resources are realistically available.

The balance between local, national and internationally source fabrication and assembly also needs to be considered to ensure that local commercial communities remain supportive of the project but the balance of local focus does not tip the balance between project progression or postponement. It is prudent and strategically innovative for a project to engage some level of local commercial community in its construction phase activities. This approach provides the operational phase of the project with an experience platform for ongoing minor projects and major maintenance activities that will have a extended life time far longer than the construction period. However, projects must remain viable from a financial perspective, NPV and other governing financial criteria may force a project to seek out and adopt the lowest cost capital development option which may entail maximised offshore fabrication and assembly. This will always be the primary risk consideration of a project owner and should be understood by local and national commercial communities. There is a strong basis of long term sense in getting a value adding project established and operational so that longer term opportunities are established and available .

Environmental Considerations

Modularisation and pre-assembly project delivery methods offer projects the opportunity to considerably reduce land disturbance requirements through the reduction in required open space land clearance for materials lay down. While this aspect has only minor cost advantages to the project, it has far greater environmental husbandry benefits. A large project may require many times the area of primary structure occupation for lay down requirements if the project is undertaken via a "stick build" delivery approach. While the clearing of land in itself is not a great risk, an environmental benefit identified and communicated as a project focus may reduce other stakeholder management risk and in therefore a beneficial factor to the overall risk profile of the project.

MODULARISATION AND PRE-ASSEMBLY SUPPLY CHAIN RISK PROFILES

In the execution phase of a project the flow of functional operations has all the affiliated characteristics of a typical supply chain. While there is a greater depth of complexity in the components of the supply chain between comparative "stick build" and modular and pre-assembly delivered projects, both types of project delivery are fundamentally a supply chain with the associated management requirements.

The increased complexity of a modular or pre-assembly delivered project does require a considerable amount of detailed planning with strategy confirmations being completed in earlier phases of project development than for "stick build" project deliveries. In a modular or pre-assembly project delivery there is limited, if any, time to make efficient development decisions on the run during project execution. In a "stick build" project delivery there is more latitude for back end loading of a project without compromising project objectives. The following key areas are considered primary supply chain elements during the execution phase of a modular or pre-assembly delivered project.

1. Engineering;

2. Fabrication and Assembly Facilities

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3. Procurement;

4. Shipping;

5. Land Transport;

6. Site Installation.

The discussion on these topics will be limited to the high level risk profiles. Individual projects will have specific, and more uniquely applicable, risk registers associated with each of these key elements.

Engineering

This area of the supply chain has the potential to introduce a range of highly adverse risks to a modular or pre-assembly delivered project if care is not taken in the early project development phases to establish development platforms where high efficiencies in work process are possible. Key early definition of the following key areas are essential for the overall flow of work and the successful interfacing with other key supply chain links.

1. Engineering design standards must be clearly defined and associated materials of construction such as steel sections, Australian, British, Japanese, Chinese, etc. The associated material specifications must be fully defined from a procurement sourcing perspective and matched to the over arching design standards;

2. The Engineering 3 Dimensional model must be established and structured in a manner that reflects the work breakdown structure of the project and most importantly, reflective of the requirement to identify modules, pre-assemblies and site erected materials from a physical quantities allocation and a contracts and procurement packaging perspective;

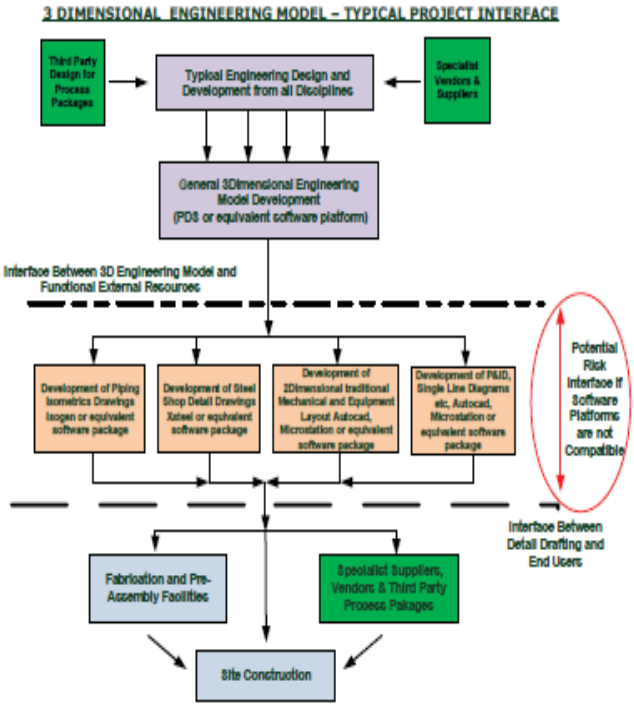
3. The strategy for the extraction of the 3 Dimensional Engineering Model information into a form that can be used to develop and issue detailed shop fabrication and assembly drawings and detail site installation drawings.

Sourcing materials of construction from lower cost offshore locations such as China improves overall project cost positions but may introduce associated risks to the project if the materials do not easily align in specification to the over arching design standards, or the materials are not able to be imported to the location of fabrication and assembly. Such a situation can exist for certain grades of steel. For instance, Chinese sections may not easily be imported to other South East Asian countries if those countries have a manufacturing capacity for a particular grade. This aspect of material sourcing must be thoroughly investigated before source location id finalized. Applicability of a materials sourced in offshore locations must be specifically matched to over arching design standards effective in the country of final installation.

The 3 Dimensional Engineering Model is the lynch pin of the overall success of a modular or pre-assembly delivered project. The project owner can not spend too much time ensuring that all aspects of the modelling are adequately addressed. The model must be able to serve the requirements of procurement and contracts as well as fabrication, assembly and site installation. Commissioning resources may also use the model.

The potential for the 3 Dimensional Engineering Model to be developed quickly and without adequate attention to the requirements of the project work break down structure and battery limits of the project scope is high. This situation produces a model that is extremely hard to interface with dependent downstream information receivers and generally requires rework with the associated additional cost and loss of execution momentum. It is essential to focus on the functionality and division of the 3 Dimensional Engineering Model before it becomes an impediment to supply chain efficiency and momentum.

As a standalone item, the 3 Dimensional Engineering Model holds a high level of internal value to a project. However, it is only when the model



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can be accessed and interpreted by resources and facilities external to the project that true value of the 3 Dimensional Engineering Model is realized; and this is only when external resources are able interpret the data in the model and convert this data into detailed workshop and site construction drawings. The external interface with the 3 Dimensional Engineering Model is extremely important to project schedule and momentum. Specialist suppliers, vendors, fabricators, assemblers and site installers all require the production of accurate detailed drawings from the model data base. It follows that a central risk to the project is the software compatibility platform that key external project resource carry, and how they are able to compatibly integrate with the project 3 Dimensional Engineering Model.

Considerable focus on this key topic is required in early project phases to ensure success during project execution. There are methods and techniques that have some basis of operational success that can be used to manage data interface during all phases of a project. The preceding diagram illustrates the general nature of the interfaces of a 3 Dimensional Engineering Model.

While these engineering related risks may appear at first to hold little supply chain significance, the reality of a project execution phase with, and without, these basic considerations finalized and cemented in strategy will be the difference in achieving project objectives within schedule and budget as opposed to on the run improvisation and corresponding chances of a successful outcome during project execution.

Fabrication and Assembly Facilities

There are a number of key aspects of an offshore fabrication and assembly facility that must be carefully considered when developing the associated execution strategy and identifying the associated risk profile. These key strategic areas are considered the most important from a high level;

1. Procurement and the facility capacity to receive, marshal, warehouse and allocate project materials and equipment to fabrication and assembly development;

2. Ability of the facility to secure, coordinate, manage and control the discharge of fabrication, modules and pre-assemblies through an export wharf or berth facility and their direct control of this key infrastructure;

3. Authority and experience of the facility to undertake and efficiently complete import and export process, documentation, and all required management task associated with import and export.

In the opinion of the author, item 2 above is consistently the most important risk aspect associated with the success of modular or pre-assembly delivered projects from a fabrication and assembly facility perspective. Although not a preferred option, most other areas of risk concern can be improved through direct supplement or support by the project to the facility. By example, there have been cases where port facilities and fabrication facilities have been provided by project with good economic outcomes. However, this level of commitment must be balanced with careful economic validation or clear strategic long term advantage to a project owner.

One area of project strategy that can be significantly beneficial is to link and integrate the offshore or off site facility management into the project execution via direct inclusion into the project management team. Key representatives from the facility should be included into the scheduling and procurement resources of the project and a facility project manager integrated into construction team of the project. This highly beneficial inclusion of facility resources into the development of the project fosters the transfer of critical information on project objectives and planning to the facility and critical feedback from the facility representatives on practical and achievable facility capacities.

The selection of an appropriate fabrication and assembly facility for the scale of a modular or pre-assembly delivered project is an extremely important aspect of the overall project delivery and resultant risk profile of this aspect of project execution. The risk profile associated with this key supply chain element is directly linked to the scale of the project requirements and the location of the facility. In general, the following overarching considerations are at the heart of the risk profile for all facilities contributing to a modular of pre-assembly project delivery.

1. Facility safety and quality systems and previous experience in completing work of a similar nature;

2. Management maturity of the facility, typical core business customers and projected order book for the duration of the specific project;

3. Ability of the facility to coordinate, integrate and manage all aspects of fabrication and assembly via in house facilities. This is especially relevant to in house capacity versus outsourced supply and has considerable impact

on coating applications, insulation installation electrical installation etc;

4. Ability of the facility to undertake and complete detailed shop drawing and engineering, by extension, there is a consideration for the software platform of the project 3 Dimensional Engineering Model.

These general overarching considerations form the general basis of more comprehensive commercial pre-qualification process which is outside the scope of discussion for this paper but is covered in more detail in the paper by the author, Modularisation and Pre-Assembly Paper #8 – Commercial Strategies.

The commercial strategies associated with the engagement of an off site or offshore fabrication and assembly facility require the flexibility to adapt easily to changes in project scope quantities and delivery schedule requirements. The ability to modify scope quantities and schedule delivery requirements within a commercial framework without unqualifiable exposure to variation claims from a facility is the key to managing the commercial risk profile associated with off site and offshore fabrication and pre-assembly facilities. There are commercial strategies that fairly and flexibly allocate and quantify the risk for an adaptive commercial model. Adaptive and flexible commercial models must closely mirror economic and estimate models based on a fundamental platform of construction commodities at the unit of measure level. When these models are used as the basis of commercial engagement of an off site or offshore facility, relationships between the project and contracted facilities can focus on project objectives. Potential for variations in project quantities or schedule are removed as a platform for a claims based execution focus.

Procurement

There are a number of potential risk associated with a modular or pre-assembled project delivery that are directly influenced, positively or negatively, by the following underlying practical considerations.

1. Source of material and equipment location in respect to the fabrication and assembly facility, logistics chain, customs and quality control sustainability considerations;

2. Ability of the project systems to confirm receipt and allocation of materials at fabrication and assembly facilities;

3. Ability of project systems to integrate bulk component deliveries into fabrication facilities and re-assign as packaged modules, pre-assemblies and site erected materials packages.

The key areas identified above are not universally encompassing but provide the reader with a starting focus in relation to the risks associated with over arching procurement systems. Early identification of potential deficiencies in system performance can be corrected in advance of the commencement of execution phases.

As identified in the previous section, the potential for offshore, and especially Asian economies to provide bulk materials of construction, specialist equipment and in some cases even technology and engineering support holds tremendous advantage for a modular or pre-assembly delivery strategy. This is especially valid if the work is targeted for fabrication and assembly in the same country. Understanding the logistics and customs interactions between countries of procurement sourcing and countries of fabrication and assembly is essential and has a profound effect on the risk profile of the procurement and logistics strategy. By example, consider a component purchased in one Asian country location at a discounted amount, the fabrication and assembly location is in a different Asian country and the material or equipment when dispatched sits in the customs clearance queue for weeks before it is identified that a duty is applicable in the destination country to protect a local industry. This is a fundamentally detrimental to overall schedule and budgeted costs. These risks can very easily be identified by a project owner through insistent early investigation well prior to the project execution phase.

For locations such as China, there seems to be great potential to link procurement of bulk materials and equipment sourced in China with China based fabrication and assembly. The opportunity appears to exist on the basis of reduced costs for procurement if undertaken by a Chinese fabrication entity within China, i.e. the procurement not being classed as an export prior to the value adding of the fabricator. This opportunity would seem to be worth exploring! However, any procurement strategy must be developed with a clear insight into the associated risk profile, the engineering and quality links must be fundamentally considered and a strategy that demonstrably preserves

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the most robust risk profile is by far the most desirable in this case. A more comprehensive discussion on procurement strategy is presented in the paper by the author, Modularisation and Pre-Assembly Paper #7 – Procurement Strategies.

Shipping

As a supply chain element for a modular or pre-assembly delivered project, oversize shipping is of fundamental criticality and importance. Without the ability to ship a module or pre-assembly the key benefits of removing construction hours from site are a lost opportunity to a project owner. In direct relation, if the cost of the shipping for a modular or pre-assembly delivery outweighs the aggregate benefit of a modular or pre-assembly delivery strategy then the benefit to the project is with a "stick build" methodology. These relationships direct our attention to the underlying requirement for a balanced strategy. The associated risk profile for a project will be intricately linked to the difference in overall shipping and transport cost and the savings made in off site and offshore fabrication and assembly facilities.

It is understood that each project has a specific risk profile associated with shipping, however, only the following three topics will be addressed in this paper.

1. The financial aspects of shipping modules or pre-assemblies;
2. The impact of commercial frameworks on shipping risks;
3. The configuration of modules or pre-assemblies and the allocation of shipping.

By far the greatest concern in regard to a modular or pre-assembly delivery with respect to shipping and financial exposure is the value of the cargo. A module or pre-assembly represents a considerable parcel of value in both direct cost and also potential schedule loss should the cargo be lost. In reality, shipments of module and pre-assembly type cargo are very seldom lost. The few isolated occasions where this has been the case can be directly traced to parameters outside the immediate realm of responsibility related to shipping. In general the shipping aspect of a modular or pre-assembly delivery from a statistical perspective of financial loss is strongly positive.

The commercial framework in which a shipper of modules or pre-assemblies is engaged by a project has a much greater potential to profoundly impact a positive risk profile than the risk of module or pre-assembly loss. The commercial strategy for the engagement and retention of shipping service providers for a modular or pre-assembly delivered project must hold considerable flexibility for variation in specific milestone departure and arrival dates for the cargo. An incorrectly structured commercial package will lock a project into prescriptive departure dates from fabrication and assembly facilities. This scenario can influence managers to dispatch incomplete modules or pre-assemblies to avoid demurrage claims. However, The greatest risk to the project is the importation of construction hours to the site. Project owners must provide considerable attention to this area of project commercial strategy to ensure a framework for contracted shipping services that does not encumber the execution phase with high potential to adversely impact the overall economic risk profile of the project. A more comprehensive discussion on contracting strategy is presented in the paper by the author, Modularisation and Pre-Assembly Paper #7 – Procurement Strategies.

"A further shipping related consideration of a modular and pre-assembly delivery strategy is the vessel unloading and subsequent customs, quarantine and bonding requirements. These key steps can be easily overlooked or omitted from early planning phases of a modular or pre-assembly delivery strategy development. "

The configuration of modules and pre-assemblies has a considerable effect on the overall risk profile for the associated shipping strategy. The key risks for shipping vary as the market demand for oversize shipping fluctuates. In general, the larger the pool of available shipping types that modules or pre-assemblies can be carried on, the lower the risk of dealing with constrained market that could command high premiums and restrictive condition in the periods when the project shipping is scheduled. There are many types of shipping options, Sea Tow Barge, Lift On – Lift Of (LOLO), Roll On - Roll Off – (RORO) and Float On – Float Off – (FOFO). All of these options have applicability to different scales of mass and dimensional size of modules and pre-assemblies. The economic studies will determine the optimum scale for shipping and transport and identify the most robust risk profile.

A very important high level consideration in regard to the overall shipping is the maximization of bulk freight in consolidation with voyages carrying modules or pre-assemblies. Maximizing this consolidation of services keeps overall shipping cost to a minimum and assists in focussing the sched-

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uling of key site erected packages such that they match site demand requirement.

A further shipping related consideration of a modular and pre-assembly delivery strategy is the vessel unloading and subsequent customs, quarantine and bonding requirements. These key steps can be easily overlooked or omitted from early planning phases of a modular or pre-assembly delivery strategy development. They are critical supply chain management elements and cause significant disruption to project execution momentum if early planning for efficient processing is overlooked.

"From the strategic and development level, the most important risk profile to quantify if that associated with oversize transportation permitting, interface with the public during transportation cycles and supporting public and project infrastructure. Permitting and government endorsements and approvals are key steps in the modular or pre-assembly delivery development and are a key risks to the project execution phase."

Land Transport

The high level risks associated with land transport of modules and pre-assembly are uniquely linked to each project. The distance from the port of shipping arrival to the final point of installation is a fundamental consideration that is linked to the mass and overall dimensions of the module or pre-assembly. The technical and economic aspects of this viability balance should always be done in early project development phases. The associated risk profile is founded in practical aspects of the transportation movements and can be readily evaluated and mitigated through the early, integrated inclusion of transport service providers in the project technical development. A practical key consideration is transport equipment fleet size and the associated resource requirements to match project schedules.

From the strategic and development level, the most important risk profile to quantify if that associated with oversize transportation permitting, interface with the public during transportation cycles and supporting public and project infrastructure. Permitting and government endorsements and approvals are key steps in the modular or pre-assembly delivery development and are a key risks to the project execution phase. The projected transportation volumes and cycle frequencies have a strong bearing on public interface and potentially safety.

The interface of large transportation volumes with public traffic is of considerable importance to both the project and government authorities, especially when project site locations are located considerable distanced from the coast. Strategic planning for transportation timing, traffic bypass and public safety are key risk considerations and require early focus and attention from project owners. Early development of module and pre-assembly transportation cycles and traffic volume histograms is essential and can greatly assist government authorities in understanding the requirements of the project and providing support. The inclusion and involvement of specialist transport providers in this area is a highly beneficial approach.

Infrastructure improvements for site access may be required for module and pre-assembly transport access in both project controlled perimeters and on public road networks. The allowance for improvements to transport corridor improvements can be significant and should be thoroughly understood early in the economic development of a modular or pre-assembly delivered project.

Site Installation

Site installation in a modular and pre-assembly delivered project has many risks specific to individual project configuration.. The following points can be used as a general checklist in the development of site installation for a modular or pre-assembly delivered project. Study of these key areas will provide the project owner with a high level overview of the prevailing risk profile for a particular project.

1. Equipment of installation such as cranes, hydraulic trailers and jacking systems and the commercial strategy for their availability during the site construction phase of execution;

2. Temporary access facilities and equipment for the integration of site erected components and the connection of modules or pre-assemblies;

3. Sequencing and temporary storage of modules and pre-assemblies as they arrive on site.

The strategy for the provision and allocation of equipment for the installation of modules and pre-assemblies is a critical consideration. Commercial strategies for the provision of a common project equipment pool, or the reliance on construction resources to provide installation equipment is decision based on the overall project benefit related

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to the balance between schedule and cost consideration. Schedule is more highly at risk through a pooled approach to equipment supply and equipment provision by individual construction resources produces situation where efficiencies and cost can be less than optimum in respect to overall project utilisation.

The ability to include temporary access such as scaffolding in off site or offshore locations prior to the module or pre-assembly reaching site has the potential to significantly reduce site construction hours. The scaffold materials can be recycled through the supply chain or pooled for future project operational use. Early design that maximizes the ability to apply specialised access such as elevating work platforms etc also vastly improve the ability to remove construction hours from site. Engineering design should be developed to account for deck loading associated with access equipment to reduce on site rigging hours and improve overall site safety. The early introduction of these concepts into the strategy developments give the greatest potential for innovative construction approaches that reduce site construction hours and overall costs.

Site based construction lay down areas are of particular importance to any project delivery method. Modular and pre-assembly projects offer the opportunity to greatly reduce the quantum of lay down required but there will still be some requirement in many cases for the temporary storage of modules and pre-assemblies prior to placement. Careful consideration to the geotechnical requirements must be made and provision for adequate supports, stands or dunnage is required to ensure that the modules or pre-assemblies are not unduly exposed to the potential of dimensional distortion. While this is not a significant overall risk, if unidentified it will place a burden of cost and unplanned workload on site civil resources during construction.

CONCLUDING COMMENTS

This paper has introduced a broad spectrum of overall risk considerations for a modular or pre-assembly delivered project. The points raised and discussed are by no means a comprehensive review of all possible risks associated with the delivery method. The level of discussion has been limited to the overarching consideration and those most applicable to the project owners attention. A myriad of practical and execution related risks exist in addition to the high level risks identified in this paper and a comprehensive risk assessment must be completed for every phase of project development and most importantly from the perspective of the supply chain management and execution.

Many risk areas are so independently related that a comprehensive risk analysis and ranking cannot be undertaken on single elements in isolation at a detailed level and must be balanced and aggregated with other elements to establish the inclusive risk profile of a specific execution strategy. The interdependent characteristics of a modular or pre-assembly delivered project dictates that the holistic evaluation of the supply chain for project execution be considered, evaluated and strategically developed in its entirety in a similar manner to the economic validation process. The brief look at the predominant risk profile heavy weights identified in this paper give the project owners and project deliverers a look general reference checklist for the high level strategic development of a modular or pre-assembly delivered project.

There is a germane saying from eastern origin that has a strong applicability to the understanding of the risk profiles of a modular or pre-assembled project, in rough translation, “in the land of the blind, the one eyed man is king”. In reflection of the risks of a modular or pre-assembly project delivery, identifying even roughly, the areas where adverse risk profiles creep into project execution and strategic direction during the early phases of project development will bring extensive positive influence to the probability that the overall project delivery will be a success given the correct mitigations are deployed and communicated.

The potential to improve the successful delivery of modular and pre-assembly delivered projects lies in the requirement to openly identify, discuss and evaluate the difficulties and challenges of previous projects delivered by these methods and from such platforms, develop and improve upon the successful strategies and elements of execution that previous project have been delivered to their project owners. Risk is always a factor of any project, the only risk free project would be one that did nothing! The risks associated with modularisation and pre-assembly are no less manageable than for any other project delivery method if they are understood, communicated openly to the project delivery team and decisively mitigated or managed throughout project execution.

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