



MODULARISATION AND PRE-ASSEMBLY PAPER #3 FUNDAMENTAL CONSIDERATIONS FOR EXECUTION

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INTRODUCTION AND OVERVIEW

This paper has been compiled to provide the project owner with general discussion on the high level considerations associated with the delivery of a project by a modular or pre-assembly execution strategy. This paper is also a supporting supplement to the paper by the author Modularization And Pre-Assembly Paper #1 - Underpinning Parameters And Considerations.

There are a number of key areas of focus that a project owner will have specific interest in throughout each development phase of a modular or pre-assembly delivery strategy. While each phase of project delivery demands focus on the key elements, there are differing levels of strategic and detailed interest. The focus on each element has strong importance right through to the final execution phase. This paper will consider the initial scoping or pre-feasibility phases as a starting platform for the fundamental considerations of a project owner seeking to establish the applicability of a modular or pre-assembly delivery method for their specific project. The topics selected for more detailed discussion are as follows;

1. Stakeholder Relationship;
2. Safety;
3. Design and Technical;
4. Procurement and Quality;
5. Fabrication Facility;
6. Commercial;
7. Shipping and Transport;
8. Site Construction;
9. Project Team.

The points above are not fully comprehensive of all project considerations. The discussion focus of this paper is principally related to modularization and pre-assembly considerations. A detailed discussion related to off site fabrication and assembly considerations is provided in the paper by the author Modularization And Pre-Assembly Paper

#6 - Offshore Fabrication And Assembly Cost Development. The risk profiles associated with the points above and other key areas are provided in the supporting paper by the author Modularization And Pre-Assembly Paper #4 - Risk Profiles.

STAKEHOLDER CONSIDERATIONS

This is an area where the qualification of overall project impact is difficult to forecast. The first step is to identify and understand the most common primary stakeholders and how they will be affected by the scale and extent of modularisation or pre-assembly project delivery. From a project owners perspective, the objective should always be the achievement of maximum project value which will translate to overall corporate and shareholder value. The most relevantly affected high level stakeholders associated with the strategic development phases of a project can be identified as follows;

- Corporate Shareholders;
- Corporate Finance Managers
(Business Model, NPV Viability);
- Local Commercial Communities;
- Local Labor Organizations.

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While there are unquestionably more stakeholders associated with the overall project, the balance of the expectations for these key stakeholders are arguably the key stakeholder balance objectives from an overall project value and success perspective. If a project is entirely focussed on maximizing project outcomes to singular stakeholders, the resulting unbalance in the contributions of the remaining stakeholders will probably not favor the overall benefit of the project. A careful bal-

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ance between business model objectives and key stakeholder objectives is of the utmost criticality in the development of a modular or pre-assembly delivered project strategy.

The expectation management of local commercial communities is also a reasonable project objective and can be seen to add value to overall project success. In recent times the global financial collapse has seen increasing pressure on local commercial communities servicing the major projects of heavy industry. This is strongly evident in Australia, North America and Europe. Careful balance of the contributions from local industry needs to be weighed against the option of total remote sourcing of fabrication, pre-assemblies or modules. On a project by project basis, there is generally some percentage of the total project quantities which is competitively assignable to local commercial communities. Similarly, local commercial communities must position their services to be competitively attractive to industrial project economics.

Industrial relations in any major industrial project is always challenging and required a committed focus from the project owner and deliverers. In a modular or pre-assembled project industrial relations and the commitment of the on site work force to the schedule objectives of the project is essential. Early communication and engagement of the work groups and labor representatives must communicate the intentions of the project to adopt the economic scale of modularization or pre-assembly applicable to the project and cement this as the delivery model that allows the project to be developed.

One key factor that all external project stakeholders must keep clearly centered as a primary consideration is that the development of any project through to commercial production, even with a less than expected initial involvement, is a highly beneficial outcome for the location of the project and is a much more attractive option than an undeveloped concept.

SAFETY CONSIDERATIONS

Safety is by far the aspect of modularisation and pre-assembly with the absolute greatest ability to improve over traditional site erected project delivery methodologies. There are two general considerations related to safety for a modular or pre-assembly delivery approach as follows;

1. Off Site Safety Management;
2. On Site Safety Management.

Off Site Safety Management

Consider the off site safety management implications for a modular or pre-assembly project delivery. One of the first questions that should be asked from a project owners perspective is whether the off site facility will be considered a project location for the purposes of safety management or it will be considered in a similar manner to say a fabricated or procured supply. This is a core safety management decision; the project can be delivered with either a full project delivery safety team present in the off site facility or not. Both methods have been successfully executed by modular and pre-assembly delivered projects.

However, modularization and pre-assembly delivery strategies are by no means vehicles for project owners to abandon their corporate safety standards and goals. Project owners can actively contribute to establishing, maintaining and in some cases improving safety standards in off site and offshore facility locations. Most facilities will

CORPORATE SAFETY GOVERNANCE CONSIDERATIONS

Moving hours off site should not suggest abdication of safety considerations or responsibility by the project owner for the project related safety standards in the off site facilities. Project safety standards can be markedly and positively influenced by the project owner in an off site facility to match corporate and project expectations by direct involvement, commercial incentive and specifications or a combination of both to achieve project expectations and requirements on safety performance.

embrace a project owners sponsored support. It is sometimes believed that lower cost high value centers for fabrication and assembly translate directly into a position of surrendered safety focus. While the safety in some less organizationally mature organisations in low cost, offshore locations do require some focused management to improve the working conditions acceptable for most projects initiated by developed nations, it should be noted that organizations in low cost centers with the technical capacity and maturity to undertake a significant modular or pre-assembly delivered project have similar, and in many cases superior, workplace safety systems to many similar facilities in developed countries. This sophistication is often the result of the influence of the Oil & Gas industry to which larger facilities in low cost high value locations provide services. Through extension of this concept it is clear that a strong con-

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cern and interest in off site safety issues can only benefit and improve corporate safety culture and the culture and standards in off site facilities.

On Site Safety Management

This is the area where modularization and pre-assembly truly shines with opportunity. The following key points highlight the primary considerations for safety applicable to a modular or pre-assembly project delivery.

1. Reduced overall personnel density in the on site construction and camp environment;
2. Reduced requirement for working at height on site. Modules and pre-assemblies should arrive on site with all fall arrest and safety lanyard harness points in place;
3. Access to multiple levels of a structure is achieved quickly with permanent access. Floor decking, mesh and grate is in place when the module or pre-assembly arrives on site which is otherwise a significant site construction hazard;
4. Pre-Assembly reduces the requirement for multiple work crews to work in concurrent vertical work spaces which have historically been the contributing environment for falling object incidents.

These key consideration and benefits of a modular or pre-assembly delivery provide a substantially improved platform from which project owners can develop and sustain workplace health and safety standards that are significantly more difficult to achieve with traditional site erected project delivery methodologies.

DESIGN AND TECHNICAL CONSIDERATIONS

This is an area where there is a requirement for a clear, and well documented and communicated commitment to the progression of a modular or pre-assembly project delivery approach. As discussed in the paper by the author Modularization And Pre-Assembly Paper #1 - Underpinning Parameters And Considerations, a modular or pre-assembly design can be site erected in the traditional manner with very little impact except for any additional steel associated with the module or pre-assembly design. However, in stark contrast, site erected or stick build designs are inherently

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unsuited for modularization or pre-assembly without considerable change, which inevitably results in increased cost and schedule. The only reasonable expectation for a stick build design when applied to a modular or pre-assembly delivery is to achieve some level of flat pack paneling for wall or roof sections. It is not an easy undertaking to convert a stick build design to a modular or pre-assembly configuration and in some cases not possible at all without extensive re-work of the base designs.

To ensure that a modular or pre-assembly design has the greatest flexibility and opportunity for success from inception there are a number of high level key areas that should be defined in the scoping and pre-feasibility phases of a project. While not comprehensive, the following discussion will offers the reader a platform for further reflection.

As early in the project development as possible, the design criteria for acceptable grades and specification of standards for structural steel must be developed such that both local and offshore sources of supply can be utilized. This is a key early factor affecting both designers and the development of cost effective procurement strategies.

Software for Engineering 3 Dimensional Models and the associated shop detailing packages must be adopted on the basis that they offer maximum access to the future fabricators and assemblers without them having to re-train in order to interpret and process project data. It is essential to build a strategy that actively identifies each aspect of engineering from computer based modelling through to detailed shop drawings and assembly marking plans at an early stage in project development, preferably the commencement of the pre-feasibility phase.

The level of computer based modeling is also essential to develop and cement in early project development phases. To what level of detail will the computer based model define the finished module or pre-assembly and associated site erected quantities? Key high cost site construction hours related to small bore piping, instrumentation, insulation and refractory materials etc need to be addressed in the detailed design strategy as these items often lead to project quantity design growth.

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Early identification of the engineering requirements, workflow and importantly the responsible resource throughout the full progression of engineering detail from concept to site installation is the only sure method of ensuring there are no practical, versus conceptual, strategy gaps. Because modules and pre-assemblies are completed in facilities off site and offshore, they are often schedule linked to shipping. Quantities are a primary factor affecting productivity capacity of facilities. By limiting computer engineering model detail, the fabrication and assembly facilities are effectively back end loaded with cost and construction hour dense commodities without schedule flexibility. Historically, this has led to shipment of incomplete modules or pre-assemblies with the associated adverse economic impact on the project. The more cost and schedule effective method is to stipulate the requirement to maximize the level of detail in the engineering model.

Another general consideration relevant to early project phase development is module or pre-assembly handling, and in particular, concepts for rigging configuration. Column Lift versus other forms of rigging have an impact on



the design strength and also the ultimate dimensional envelopes of modules and pre-assemblies. The pictures to the left show the rigging configurations as described. The rigging configuration in the upper picture introduces transverse compressive load to the structure which requires additional structural rigidity generally obtained from additional steel. The rigging configuration in the lower picture uses a square frame rigging configuration lifting directly from the structures support columns. Both handling configurations offer benefits and limitations to the designer. Smaller, stronger structural envelopes can be handled by Lift On - Lift Off type vessels such as the upper photo, while larger module



or pre-assembly similar in configuration to the structure in the lower photograph will probably be suited to a Roll On - Roll - Off style of shipping configuration. The balance between handling, shipping and transport is a strategic objective of early economic evaluations.

PROCUREMENT AND QUALITY CONSIDERATIONS

The integration of the most effective and cost beneficial procurement strategy can significantly increase the economic viability of a modular or pre-assembly delivery methodology. Inversely, a poorly matched procurement and modular or pre-assembly strategy can undermine the overall value of both strategies. The location of off site fabrication and assembly facilities has a strong influence on how efficiently a procurement strategy will support a modular or pre-assembly strategy. Material and equipment purchase cost, source location and associated logistics, (inclusive of the ease of import export into the country location of the fabrication and assembly facility) must be carefully balanced for maximum project value.

At the core of the procurement strategy, a fundamental decision on the holder of procurement responsibility must be made. Procurement responsibility can rest with either the project owner or delivery resource, or it can be passed to the fabrication and assembly facility. Both options hold benefits, advantages and limitations for procurement execution and project value. If the project holds the responsibility for procurement then it must carry the responsibility from upstream vendor and supplier quality control through to receipt, storage and security and finally free issue to the facility. If the project elects to transfer the procurement responsibility to the facility, reasonable premiums should be expected for some materials and equipment, but, in some cases, commodities of construction such as steel may be secured at attractive rates.

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The purchasing strengths and specialities of facilities should be centrally considered in the overall procurement strategy. In general there will always be some requirement for a facility to receive owner supplied equipment. Additionally, at some point modules or pre-assemblies and fabricated items will be shipped from the facility. This requires the facility to have a considerable ability understand the relevant local import and export requirements the ability to facilitate smooth execution with the local authorities. This aspect of administrative requirement should not be un-

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“The expense of a poorly resourced quality control program in off site, and especially offshore fabrication and assembly locations, can be the disastrously adverse situation of importing high cost construction hours to site.”

derestimated. One of the most important aspects of procurement, fabrication and assembly in off site, and in particular offshore facilities, is quality control. In most larger offshore facilities there is a level of quality certification, however, in many regions, quality systems are sometimes not fully integrated with the quality control required in project in developed countries.

To ensure that a project achieves quality objectives, it is essential that adequate inspection and technical resources are assigned in the appropriate geographic locations to identify and address quality issues immediately if they arise. The expense of an under resourced quality control team for off site, and especially offshore fabrication and assembly location quality control can lead to the disastrously adverse situation of importing high cost construction hours to site. The quality control team that actively focuses on production quality control and inspection that integrates with the upstream vendors, suppliers and the fabrication and assembly facilities will add significantly more project value than an equivalent pursuit of structured quality assurance management systems in the same locations.

FABRICATION & ASSEMBLY FACILITY CONSIDERATIONS

While there are many consideration related to off site and offshore fabrication and assembly facilities, the basic beneficial relationship of these facilities to a modular or pre-assembly project delivery rests in their ability to dedicate a focused and committed service to its customer. At first glance, this may seem to be an area of little concern given these facilities are developed, geared and exist to serve international projects. However, given the nature of a projects owners core business i.e. oil & gas, petro-chemical, mining, minerals processing, power or general heavy industry, the level of potential for ongoing opportunity has an influence on the facility owners.

Repeat business is a tremendously powerful motivation for fabrication and assembly facilities across the world. This key element is very prevalent in the oil and gas industries but sometimes

hard to establish in other industrial sectors, especially the mineral processing and heavy industrial sectors. As such, a project must try and achieve the matching of facility focus, required capacity, safety and quality requirements essential for the project execution success. A key factor that the oil and gas industry benefit from with respect to facility interest is the high construction hour density per square meter in facility real estate occupancy. Many minerals processing and mining projects have sparse construction hour density on a module or pre-assembly basis when compared to oil and gas or petro-chemical type modules and pre-assemblies. However, it is still possible to secure the interest of high calibre facilities given adequate tonnages and willingness of the project owners to compensate the facility for services such that the required focus and commitment to project objectives is secured.

Another fundamental consideration that is central to the success of a modular or pre-assembly delivery is the ability for a fabrication and assembly facility to directly access a load out berth or wharf. This is a basic requirement for modular and pre-assembly without which there is little opportunity other than complex pre-fabrication and panel type pre-assembly. It is a strong preference that a facility of choice would have an in house berth or wharf which they are in complete control of for the purpose of load out. It should be noted that while it would be very convenient, facility berths or wharfs are seldom permitted for importation and bonding and even if they are, the logistics of importation shipping is outside the scope of their expertise.

Another key aspect related to off site and offshore facilities, once they are established as project resources their utilisation needs to be maximized. The positive economics of Modular and pre-assembly delivery is improved by increasing the aggregate of the construction hours performed off site. This is improved further by increasing the aggregate in any single or closely grouped set of facilities such that the logistics cost can be minimized and the maximum freight can be carried on any one vessel voyage. This does not suggest loading a single facility to the point of detrimental consequence to the project risk profile, rather, careful allocation and matching of fabrication and assembly capacity with shipping cost focus to a point where the facility can become a general procurement marshalling point.

As a final point of note many projects will investigate pre-cast concrete as economically viable to undertake in off shore facilities. It is not common for fabrication and assembly facilities to hold sig-

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nificant expertise in civil works outside the foundation bases for module and pre-assembly construction. Pre-cast concrete most definitely involves another set of engineering and practical discipline skill not held by facilities traditionally undertaking modularization and pre-assembly. These skill usually have to be integrated into the facility by the project. However, this requirement does not preclude successful pre-cast development. If a project can establish some depth of pre-cast expertise in the facility then form and shutter preparation can be added to the potential off site activities further improving the overall viability of a modular or pre-assembly delivery strategy.

COMMERCIAL CONSIDERATIONS

The most important high level commercial consideration for a modular or pre-assembly delivered project is to ensure that the basis of contract development and strategy is integrated with the project work breakdown structure such that there is an ability to frame contracts around work breakdown structure. This is extremely important when multiple facilities are engaged for fabrication and assembly and how site erected quantities are allocated. There is strong potential for duplication or omission of these key items if an integrated commercial structure is not developed early in the project development phases and linked to the work break down structure and the associated 3 dimensional computer models.

The other key high level commercial consideration is to ensure that the commercial agreements are predicated on the unit of measure basis at a commodities level which are the fundamental building blocks of modules, pre-assemblies and site installed quantities. This platform of commercial execution as applied to off site and on site construction will flexibly allow for variation in project scope quantities while retaining a robust risk profile for the project. Some measure of predictive variation must be established in the associated contractual agreements but these measures are not difficult. Shipping commercials should be centered around dedicated charter whenever possible and flexible provisions provided such that project schedule milestone dates do not drive behavior that causes incomplete modules or pre-assemblies to be shipped and also allows the shipping

SHIPPING AND TRANSPORT CONSIDERATIONS

Oversize shipping is a primary consideration for modular and pre-assembly delivered projects. The most essential consideration is the ability of shipping resources to be able to interface with a proposed fabrication and assembly facility's berth or wharf. The high level considerations for the shipper will be location of facility and ability for their specifically flagged vessels to berth at the facility location. More practical high level considerations relate the facilities nominated berth or wharf and the associated tidal ranges, deck capacity and tonnage rating etc relative to proposed cargo and the individual vessel ballast capacity and draught requirements. This fundamental information is required early from the project in order for vessel owners to propose appropriate options for the project delivery.

From a direct shipping perspective, the associated dimensional and mass scale of a module or pre-assembly has strong implications on the type of shipping used to transport the oversize cargo to its port of location. The generally available types of oversize shipping are Float On - Float Off (FOFO), Roll On - Roll Off (RORO), Lift On - Lift Off (LOLO) and barge towed. All these shipping options have application to the spectrum of modular and pre-assembly delivery with associated economic impact on the delivery strategy. Vessel pool size and availability generally shrinks as the scale of modularization increases. The balance between module and pre-assembly scale needs to be carefully offset with vessel pool availability and associated oversize and bulk freight cost. Maximizing the utilisation of dedicated project voyage charters such that the entire vessel can be loaded with oversize and general bulk freight for project site delivery is a strong strategy.

Land transportation is not as intricately complex as the associated oversize shipping aspects of a modular or pre-assembly delivery program. However, module and pre-assembly scale and mass require the highest level consideration in respect to the physical transportation distance from which the site destination location is from the point of pick up. In general, longer transport distances will be more suited to a pre-assembly type strategy due to their lower mass and dimensional characteristics. This will allow for the utilisation of lower complexity and cost equipment.

The project location may also have a strong impact on local communities and public roads. The

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proposed transit corridors should be pre-approved by appropriate officials and government departments in the early phases of project development. Corridor limitation will be a major and uncompromising restriction on mass and dimensional parameters associated with a modular or pre-assembly delivery strategy.

SITE CONSTRUCTION CONSIDERATIONS

This area of project focus, planning and committed development can have an outstanding effect on project success if early phase project resources are applied. One of the single most important consideration for site development with respect to a modular or pre-assembly delivery strategy is the readiness of the site to receive the modules or pre-assemblies. In the event that a project has a wharf or berth component, the allocation of focussed early works endorsement and funding can greatly increase the efficiency of a modular and pre-assembly execution with strongly beneficial flow on effects throughout the entire project execution. There is strong historical project execution evidence that lack of decisive development of supporting and preliminary construction or adequate capacity to receive modules and pre-assemblies has a dramatic affect on early execution and subsequently overall project momentum. Invariably, the resultant schedule slip is difficult and in some cases impossible to rectify.

One key area that can be overlooked as a requirement in latter project execution is quarantine and customs facilities. This can be a very detrimental oversight in any country. The preparatory civil infrastructure for module and pre-assembly transport corridors is also a fundamental limitation to project progress if they are not in place to match project schedules, early commitment of resources and funds for this key set of activities fundamentally ensures the platform for smooth and successful project execution.

Commitment for early preparatory works is a contentious issue for many project owners. Early commitment of funds can have detrimental effect on tight project NPV characteristics and economic balances. On historical reflection of the resultant outcomes of projects lagging in preparatory readiness, there is significantly more impact associated with not allocating funding to early preparatory works. Given that this early preparatory work funding can only be endorsed through the project owner, there is a depth of consideration required to allocating expenditure to overall project risk

profiles.

While there are many other practical site considerations, these rudimentary considerations remain a pivotal element for project success.

PROJECT TEAM CONSIDERATION

A project team for a modular or pre-assembly team needs a considerable paradigm shift from traditional site erected project delivery if the maximum benefits of the delivery strategy are to be realized.

From a fundamental perspective, the requirement for the integration of key resources into a project are more defined in a modular or pre-assembly delivered project. These resources are typically;

1. Fabrication and assembly engineering, procurement and logistics personnel;
2. Oversize shipping agents or vessel owners;
3. Oversize land transport service and equipment providers;
4. Heavy lift service and equipment providers;
5. Quarantine and customs officials;

While these key project contributors are not exhaustive on a specific project by project basis, it gives the reader a feel for the general contributing parties central to modular and pre-assembly success. These key external resources should be fully integrated into the project team for maximum benefit. In the early phases of a project, prior to securing execution phase contracts, experienced resources from these key external service and equipment providers can be engaged on a consultancy basis. While it is possible to employ in house project expertise in these areas, such resources have no "skin in the game" from a future commercial commitment perspective and will draw the bulk of specific practical solutions from external service and equipment providers. The better solution is to have a strong practical representation from the external groups and hold overall in house managerial coordination to focus project objectives and goals into team based objectives and goals.

The execution construction management of modular and pre-assembly delivered projects is also significantly different from traditional site erected execution methodologies. The fundamental

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center of gravity related to resource location and construction hours is by nature shifted to an off site location. It is not reasonable to assume that there should be a reduced focus on supervision or quality resources in an off site location then there would be for a traditional site erected methodology. As such, adequate personnel with appropriate skills and experience in management and quality control supervision must be located in the off site facilities during the full execution of the fabrication and assembly process. It is often possible to very cost effectively supplement expatriate resources with local personnel with the required qualifications and experience if the facility is in an offshore location. In fact, it is often possible to substantially increase the supervisory and quality resource strength in offshore hand overs at, or less than, an equivalent cost in a traditional site erected execution methodology. There is a strong requirement for a consistent, (no gap in cover, with adequate overlap prior to R&R hand over), presence in off site and offshore facilities by adequately experienced supervisory and quality personnel that should not be underestimated.

An important consideration for a modular or pre-assembly delivered project is the organizational structure and geographic placement of personnel throughout project execution. If a project seeks to mirror and apply typical site erected project delivery organizational models to a modular or pre-assembly delivered project, there will be a diminished overall organizational efficiency. Applying a traditional organizational structure to a modular or pre-assembly delivered execution introduces the possibility of creating vertical silo type responsibility interfaces into the project team with the subsequent interface and integration conflicts. A more effective approach is that of geographically locating key construction management and supervision such that they have dynamic mobility to be present in the location where the current core project work is being undertaken.

Construction managers, senior construction supervision and technical, (inclusive of survey team), personnel that have final responsibility for site installation works should have active, consistent and extended involvement in engineering constructability development, off site assembly and final site construction and installation. In order to achieve this, these key personnel must cycle with the project development "center of gravity". It is essential that these key personnel have a initial and lasting commitment to the ownership of the project works. While an off site facility can have a resident core facility management and quality team, the key construction personnel must accompany the phases of the work associated with

their area of responsibility. This key shift in organizational structure and personnel deployment is fundamental to the success of a modular or pre-assembly delivered projects of the future.

For a modular and pre-assembly delivered project, the ability of the project owners and delivery resources to customize, develop and continuously adapt a flexible organizational structure to meet the critical demands of a project in execution holds tremendous cost efficiency potential. In addition to the cost efficiencies, there is extended opportunity to minimise overall numbers of personnel required for project completion in the final site location and provide a stronger overall management team in off site facility locations with no additional burden to overall project personnel number.

CONCLUDING COMMENTS

There is a wider spectrum of high level considerations applicable to every specific project scenarios and environment parameters that have not been discussed in this paper. However, the key points as discussed should lead the reader to critically appraise their specific project environment, governing parameters and stakeholder influences and requirements with a view to identifying their associated primary high level considerations related to their specific project. The fundamental point of note with regard to a modular or pre-assembly delivered project is that the delivery from a supply chain perspective is different from a traditional site erected project delivery model. The development and execution through all phases of modular and pre-assembly project development and delivery require a paradigm shift from traditional delivery techniques and long standing traditional project delivery parameters in order to achieve the maximum value yield for the project. 