International Construction Consulting, LLC

Modularization Overview

Presentation Overview

1. Modularization Overview
2. An Alternative Construction Method to Deliver Projects
3. Quick Selection Criteria for Modularization
4. Advantage and Disadvantages of Modular Construction

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Modularization Overview

- Modular Construction is a method for building portions of a project (modules) remote from the permanent construction site.
- The module(s) are built off site to the maximum economical and manageable size possible.
- The assembled module(s) is transported to the final permanent site by either one or a combination of road, rail, waterways and air modes for installation (integration)

Modularization Overview

Challenging Market Conditions

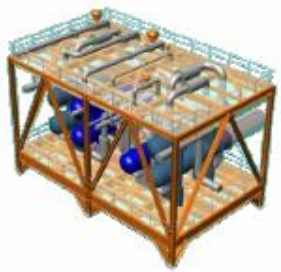
- Adverse site and local area conditions
- Difficult permitting and regulatory compliance
- Limited plot space
- Labor availability and quality
- Difficult labor conditions and high labor costs
- Productivity issues
- Extreme weather conditions

Demanding Project Drivers

- Competitive conditions (market share)
- More demanding schedules (requirements to get product to market rapidly)
- Improved safety, quality
- Cost savings
- Project feasibility and risk

Alternative Construction Methods

- Prefabrication (e.g. prefabricated buildings
- Preassembly (e.g. pre-assembled racks)
- Modularisation (e.g. skid-mounted units)



Modularization Overview

Modular Project Drivers

- Remote Location
- Extreme Weather
- Availability of Experienced Work Force
- Existing Infrastructure
- Major contracting entities
- Strong Labor Union or Relations issues
- High Labor Cost
- Schedule
- Safety
- Impact on Local Community

Modularization Overview

Modular Project Benefits - General

- Reduced Schedule and/or Flexibility
- Reduction in overall manpower and resources on site
- Reduced risk of Budget/Schedule overrun
- Reduced Re-work
- Quality Assurance
- Increased Construction Safety
- Earlier Start-up / Return on Investment

Modularization Overview

Modular Project Benefits - Safety

- Minimizes necessary work in hazardous areas when adjacent to operating units
- Reduces the number of workers and types of trades working in the area at the same time
- Reduces worker's exposure in areas from working at heights
- Reduces the exposure from other work overhead
- Allows work to be performed without added safety requirements on site.

Modularization Overview

Modular Project Benefits - Schedule

- Shortens schedule through parallel activities and improves productivity
- Maximizing assembly prior to on-site construction has the potential to reduce shut-down time in operating units
- Utilizing multiple fabrication sites with improved shop productivity can result in delaying start of assembly for business reasons
- Schedule compression from multiple fabrication sites results in early stat-up benefits

Modularization Overview

Modular Project Benefits - Schedule

- Off-site assembly allowed to start prior to on-site permitting for environmental and construction
- Reducing schedule risks associated with weather or labor conditions resulting in limit of risk of schedule penalties

Modularization Overview

Modular Project Benefits - Construction

- Construction of Modules/PAU completed in parallel with foundation & infrastructures
- Multiple work fronts and choice of locations provide additional flexibility
- Module/PAU partial mechanical completion in the yard
- Consequential delay by site preparation/ foundation on critical path are avoided
- Less congestion on site
- Completion of sub-surface work earlier without interference from above ground works
- Can reduce on-site direct man-hours by 20%
- Can reduce peak onsite manpower by 10%

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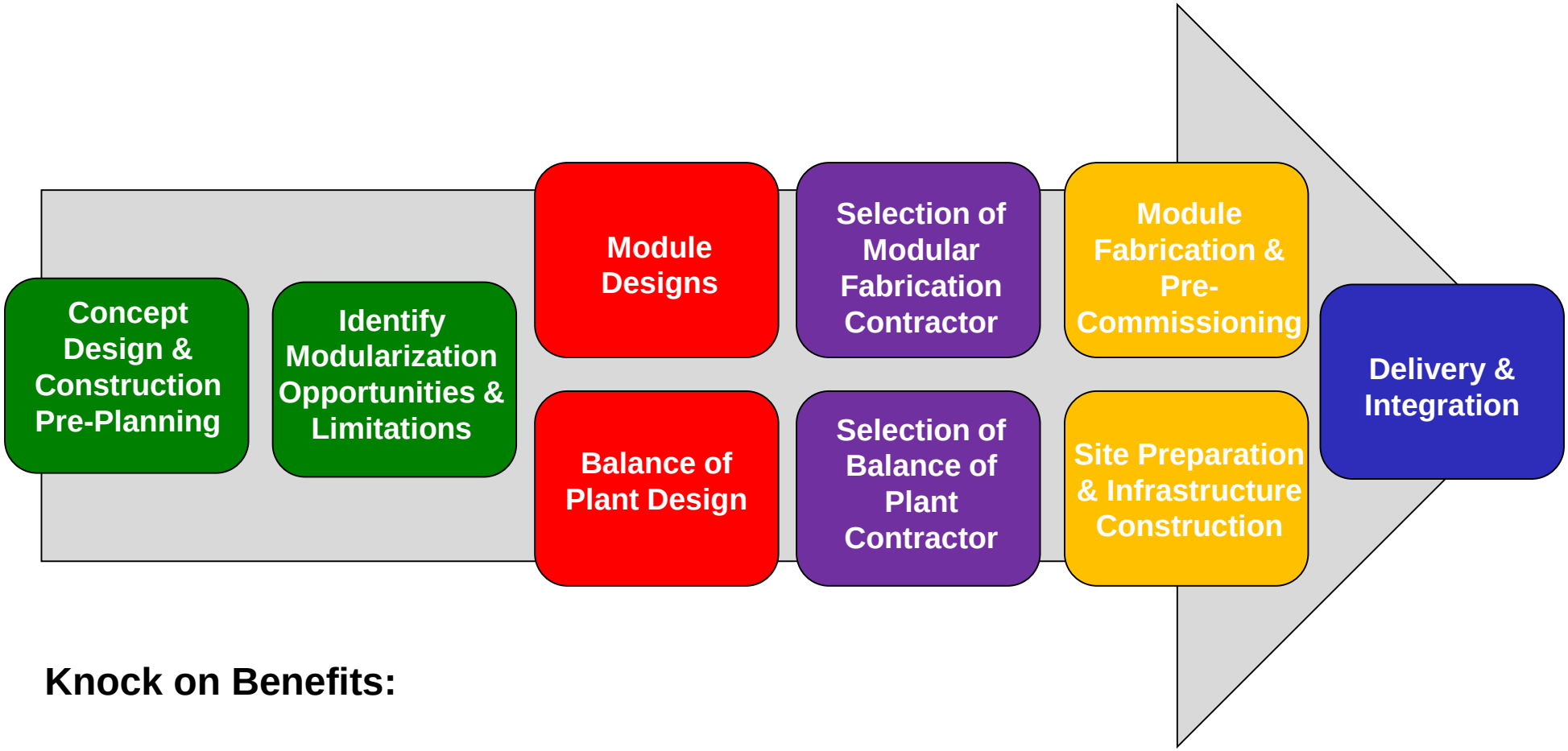
Alternative Construction Method to Deliver Projects



Knock on Benefits:

- Compress schedule (civil work while pre-assembling)
- Improve critical path
- Reduce costs

Modularization Overview

Critical Elements of Design

- Thorough understanding of modularization drivers and limitation by all parties involved
- Develop module design guidelines, criteria and limitation based on land/sea transportation and construction taking into account the plant operations requirements
- Develop optimum module/skid concept as applicable to facilities and modify GA's based on module/skid size and functional requirements.
- Complete module definition incl. Size, weight and COG
- Review module definition with design/construction team to ensure that it is technically feasible, can be transported & erected as well as operationally with no added constraint.
- Signed off PFD and frozen layout including vendor data

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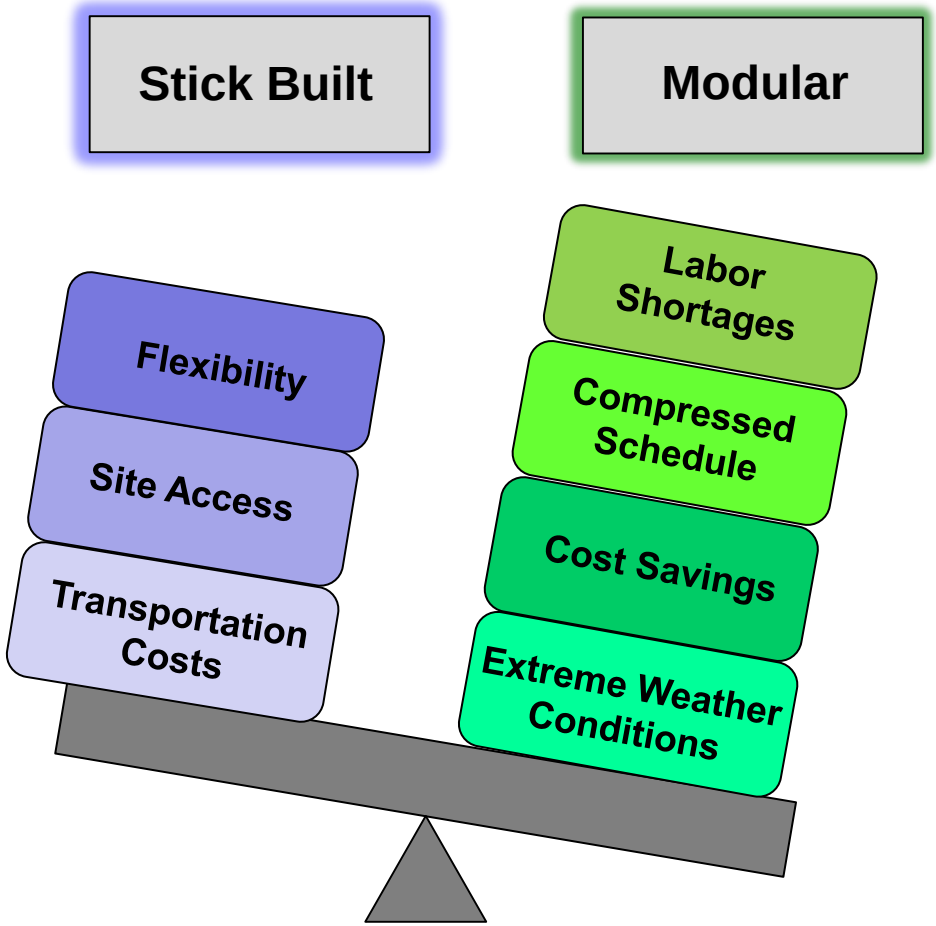
Modular Selection Criteria

Develop the most efficient construction strategy for the Project.

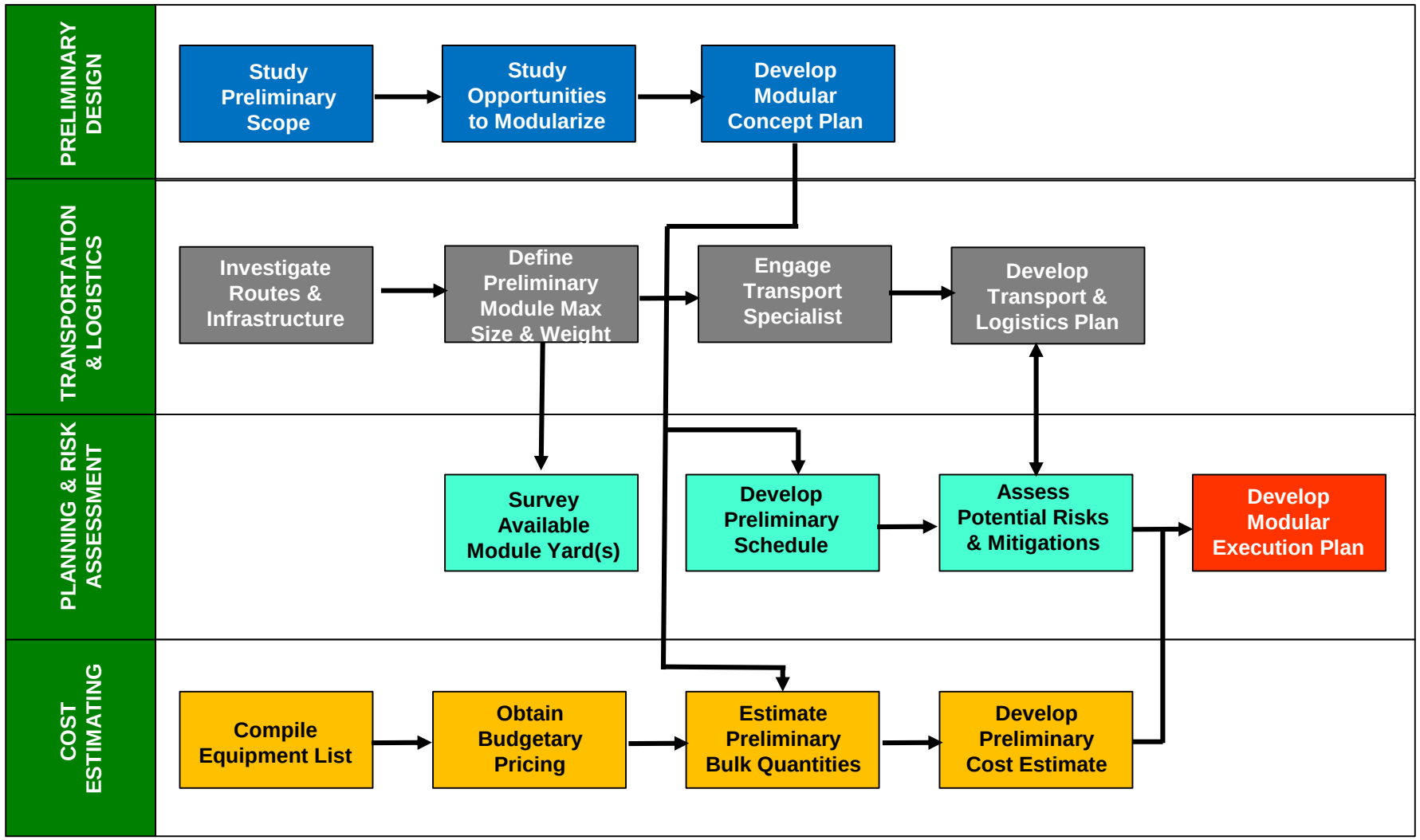


Modular Selection Criteria

- ✓ Field labor productivity is much less than shop productivity
- ✓ Field labor costs are higher than shop labor costs
- ✓ Weather may affect the construction phase
- ✓ Plant process/system allow modularization
- ✓ Local labor requirements do not restrict use of modular construction
- ✓ Transport envelope allows transportation of economical modules size / weight
- ✓ Site permits and regulatory approvals are not readily available
- ✓ Lifting and transportation available, economical
- ✓ Fabrication capacity is available
- ✓ Schedule is important or critical

Modular Selection Criteria

Front End Planning and Modularization Flow Chart



Modular Selection Criteria

Early Design Considerations

- ✓ Layout for fully pre-assembled/modularized plant has a footprint of 82% to 85% of Stick Built Layout that results in reduced piping, cable and steel quantities
- ✓ Plant arrangement accommodates vertical layout rather than horizontal layout
- ✓ Tanks to have at least 2:1 height to diameter ratio
- ✓ Incorporate localized control room/switch gear rooms into pre-assemblies to allow partial pre-commissioning off-site
- ✓ Layout to accommodate double columns for adjacent pre-assemblies

Modular Selection Criteria

Early Design Considerations

- ✓ Elevation of plant areas and foundation projections to allow access/egress for pre-assemblies
- ✓ Underground utilities to be routed to prevent damage when pre-assemblies are transported
- ✓ Plant roads to be designed with sufficient width for pre-assembly transportation including turning radius
- ✓ Piperack column spacing's to allow sections of piperack to be assembled off-site
- ✓ Structural design for bolted connections rather than welded for pre-assembly hook-up

Modular Selection Criteria

Engineering Considerations

- ✓ Process engineering, design criteria, plant layouts and plot plans, specifications, procedures and interfaces must be designed with a clear vision of the ultimate plan for a modularized plant
- ✓ Modular plants require all engineering, planning control and execution on a modular basis
- ✓ The engineering will be constrained by vendor data from procurement and will in return constrain the provision of the MTO's

Modular Selection Criteria

Significant Lessons Learned

- Front end engineering is a must
- Freeze design and adopt no change policy
- Involve marine warranty surveyors and project insurance underwriters sooner than later
- Preparation of modules for sea voyage
- Layout in the yard should be similar to site
- Detailed module by module schedule

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Advantages

+ Improved safety
+ Schedule compressed (civil work while pre-assembling)
+ Shorter onsite duration
+ Less field labor required (lower work density)
+ Cost of housing the field labor at site is reduced
+ Higher shop productivity
+ Weather related delays are minimized
+ Benefit from cheaper labor in low wage area or country
+ Lower overall project costs
+ Quality is improved (controlled work area)
+ Permitting advantages
+ Reduce plant footprint
+ Simplified foundation requirements
+ Decreased site risks

Modular Selection Criteria

Disadvantages

- Additional front-end planning
- Early decision whether to modularize or not
- Additional engineering & design considerations
- Additional transportation logistic considerations and costs
- Additional interface considerations
- Less flexibility for design changes
- Increased structural steel required
- Estimating & cost control are much more complex
- Insurance costs more than conventional
- Layout of plant critical for access
- Rejection to take work outside the country (local content)

Have questions, need additional information, or a more detailed assessment?

Contact me at:

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