NAC Executive Insights

Modularization

Key Points

- Modularization represents a fundamentally different approach to project delivery compared to the more traditional "linear" stick-built approach to facility design, procurement, and construction.
- The principle modularization driver is often schedule.
- Focus on construction driven project execution by breaking traditional program precedence and concurrently designing, procuring, building, and commissioning to the maximum degree possible.
- The modularization frontier can be thought of as a function of the **attractiveness** of modularization and the **degree** to which it is readily achievable on a given program.
- A number of factors to be comprehensively considered in modularization are laid out.
- Lessons learned in modularization are provided from four perspectives: project management; fabrication yard management; procurement/logistics; and engineering.
- Modularization requires the management of new risks.
- Lack of on-site workforce availability is a key driver for increased modularization that is fabricated off-site.

Introduction

Modularization and preassembly are construction techniques in which all or part of sections or facilities are prefabricated or assembled in one location and then transported to the site. Stick-built is a term that refers to a facility being constructed totally at the project site.

Today, the delivery of complex construction programs increasingly requires consideration and utilization of modularization and preassembly strategies. The use of these project execution methods is being driven by a mindset change that seeks to implement a Leveraged Execution and Procurement (LEAP) approach to achieve strategic business objectives that underpin the program's objectives. Modularization and preassembly are one strategy often employed as part of LEAP.

The LEAP approach in turn is shaped by one or more fundamental program drivers that seek to gain schedule, cost, or quality advantages by opening up additional construction fronts, changing build methodologies and compressing the overall program delivery cycle by overlapping execution activities, and breaking traditional construction precedence logic.

Leveraged Execution and Procurement (LEAP)

Leveraged Execution and Procurement (LEAP) represents a fundamentally different approach to project delivery than the more traditional "linear" stick-built approach to facility design, procurement, and construction.

LEAP begins with construction-driven execution thinking. This means the focus is on how the project must be built in order to achieve the strategic business objectives the organization has defined for the program. Increasingly, the principle driver for a LEAP approach is schedule, recognizing the value of time to market or as a strategy to control high construction escalation rates or reduce risk exposure periods. Other drivers, however, are possible. These include transferring activities to lower cost locations or improving the quality of construction by relocating certain work from harsh environmental or poorly trained labor regimes.

Table 1 - LEAP Schedule Drivers
Value of time to market
Control or limit impacts of high construction escalation rates
Reduce risk exposure periods
Transfer work to lower cost locations
Improve quality of construction for projects in harsh environments
Transfer work to more qualified labor force
Transfer work to higher productivity regime
Enable parallel construction by creating new work fronts

Once a strategy has been selected for how to build, a decision must be made on how to best buy out the various elements of the project as well as identifying the engineering and construction labor required. These decision sets are constrained by the construction strategy selected and in turn affect the nature, detail, and timing of engineering, procurement, and contracting activities.

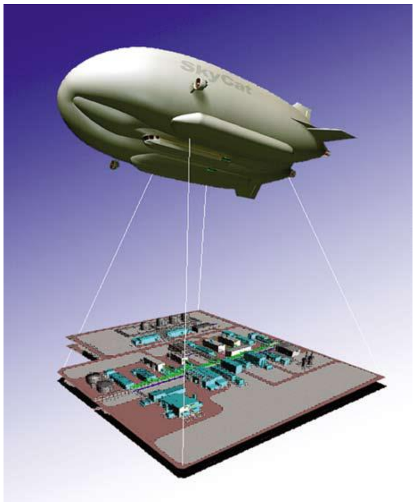
Leveraged execution and procurement builds on four key concepts:

1. Focus on construction driven project execution by breaking traditional program precedence and concurrently designing, procuring, building, and commissioning to the maximum degree possible.
2. Develop a programmatic mindset and seek to leverage each effort across the entire program.
3. Address the changed management requirements that leveraged execution and procurement utilizing modularization requires.
4. Use knowledge management and sharing as a key driver to program success.

The Degree of Modularization and Preassembly Defined

In trying to define the degree of modularization or prefabrication desirable, it is important to keep sight of the strategic business objectives the program seeks to achieve as well as the program drivers that are applicable.

As a real world example, in discussing modularization as a strategy with an owner who had not previously employed it as a delivery strategy and who was unfamiliar with what was possible, a simple question was posed: “If we could fly your whole plant in and put it at the final site, would you care?”



The magic of computer graphics aside, this is not a likely scenario, at least not yet. There are degrees of prefabrication and modularization possible, however, and different solution sets for each program. This “modularization frontier” can be thought of as a function of the **attractiveness** of modularization and the **degree** to which it is readily achievable on a given program.

Attractiveness may be viewed as considering:

- Installed cost differential (labor, material, logistics)
- Value of time to market
- Site labor constraints
- Environmental and community impacts
- Risk mitigation

Similarly, **the degree** of preassembly or modularization may be viewed as considering:

- The ability to break precedence, in effect allowing the sequence of construction to be significantly modified.
- The size of modules that can be fabricated and transported to a specific site.

Modularization
Modules are generally structures in excess of 1,000 tons (may be smaller) with physical dimensions outside conventional highway transportation envelopes. They incorporate significant high-value labor hours and are typically multi-trade. Later generation modules include all structural components, including integration/elimination of pipe racks. Piping is maximized, including small bore piping, required insulation, electrical tray runs and terminations, instrumentation and controls, and other equipment. Bracing to handle shipment related loads are often included as part of the final structural design.

Preassembly
Preassemblies are typically in a 50- to 600-ton range. Preassemblies are typically structural and generally exclude major electrical, mechanical, or process equipment. Pipe racks and cable trays may be included. Structural components typically encompass all such components, including major structural members, plate, ducting, and decking (excluding site poured concrete). Handrails, ladders, and permanent platforms are included to enable site installations.

Prefabrication
Prefabrication refers to site erected elements that have been fabricated and assembled offsite. They may include complex or repeating structural steel elements; complex concrete shapes that require precise formwork that may not be readily created at the sites; prefabricated pipe spools integrating raw pipes and pipe fittings (elbows, flanges, tees); and underground duct boxes.

Factors to be Considered in the Modularization Decision

As one goes through the process of evaluating what can be modularized and, more importantly, what *should* be modularized in order to achieve the organization's strategic business objectives, a number of factors must be comprehensively considered. Broadly, the factors to consider in making the decision to modularize and to what degree include:

- Strategic business objectives and opportunity value
- Program drivers: schedule, cost quality, HSE (Health, Safety & Environmental)
- Site-based factors: seasonal impact, environmental mitigation, labor availability
- Modularization constraints: site access limitations, route constraints, lift factors
- Supply chain reconfiguration: changed sourcing impacts, duty or tax posture
- Candidate mod yard factors: political, yard resources, bonded warehousing
- Program management factors: supervisory, cross cultural, and currency factors
- Political and labor relations impacts: work rules/agreements, direct, indirect

Table 2 summarizes some lessons learned in large scale modularization efforts and provides guidance to project management, managers at the fabrication yard, procurement and logistics organizations, and engineering. The changed sequence of work as well as the changes in the focus and levels of effort of the various activities when compared to traditional construction approaches are highlighted. Modularization changes the sequence of all project activities.

Table 2 – Lessons Learned in Modularization			
Project Management	**Fabrication Yard Management**	**Procurement/ Logistics**	**Engineering**
Modularization decision should be made at concept selection	Address fab strategy during concept selection	Set up material management by module	Increases engineering effort by approximately 10-20 percent (support details, vibration analysis, emergency shutdown, electrical/controls systems
Modularize/prefab everything possible	Fab strategy should include how to select onboard module fabricator as early as possible	Must be clear on what goes to fab yard, what goes to site	Drives engineering and deliverables to an earlier schedule
Module breaks/turnover system boundaries on early FEED (front end engineering design) deliverables	Should address maximizing pre-commissioning/ commissioning in the fab yard	Which spares go to fab yard, which to site	Engineering must know the transportation details before the start of detail design (barges, transporters)
Interface management is critical	Material control in the fabricator's yard	Procedure to transfer ownership of spares from fab yard to site	Need to organize by module
Assign project management responsibility and schedule the project by module	Fabrication yard is a construction project – manage it appropriately	Detail logistics planning early – transporters/barges drive a lot of engineering	
	Project management team at the fab yard	Mmaterial/equipment purchased/delivered earlier, causing advanced funding	

Stick-Built vs Modularization Cost/Schedule Comparisons

Modularization as part of a leveraged execution and procurement strategy offers great opportunities. Table 3 provides a summary cost comparison between modularization and stick built.

Table 3 – Module Construction Cost/Schedule Comparison			
Comparative	**Stick Built**	**Modularization**	**Comparison**
Construction Execution Flexibility	Standard	Reduced	Construction execution methodology established early in project.
Work Sequencing	Standard	Increased	Module installation opens up multiple work fronts simultaneously.
Module Testing in Shop	N/A	Increased	Economies of scale for testing program. Shop environment increases productivity.
Effect of Late Changes and/or Rework on Cost/Schedule	Standard	Magnified Impact	Field construction duration reduced. Work completes faster so changes more likely to affect completed work.
Hourly Cost of Labor	Standard	Reduced	Shop labor typically less costly than field (rate plus expenses, plus temp living).
Productivity of Labor	Standard	Increased	Shop labor typically more productive than site.
Number of Field Welds	Standard	Reduced	Most field welds done in module yard. Reconnect and closure welds performed at site.

Special Risk Factors in Modularization

Modularization requires the management of new risks (see Table 4). The management of these risks requires a broader, more programmatic perspective based on achieving strategic business objectives. The new risks span the gamut from availability of required facilities and transport to new labor, economic, and political risks. As in any risk management effort, successful management and mitigation start with the recognition that risks exist.

Special risk factors include:

- Available mod yard and preassembly facilities and yard commitment lead times.
- Reliance on specialized transport, RORO (roll-on/roll-off) or LOLO (lift-on/lift-off).
- Labor relations complexity, including labor disenfranchisement with the use of a mod yard and industrial relations issues.
- Economics of management and decision frameworks with currency exchange, inflation, differential labor costs, and escalation in labor costs.
- Other exposure to duty, tariff, tax, and export/import control regimes.
- Political stability and cross-cultural risks.

Table 4 – Modularization Risks
Availability of required facilities (module yard; preassembly)
Availability of transport (transport of construction materials to module yard; transport of modules to final project site)
New labor risks at module yard
New economic risks at module yard location
New political risks at module yard location
Module yard lead times
Reliance on special transport equipment (SPMT (self-propelled modular transporter); RORO, LOLO)
Labor relations at final construction site
Effectiveness and economics of management
Multi-currency regimes and need for hedging
Differential costs of labor and differential labor escalation rates
Modified exposure to tariffs and duties
Changed export and import control regimes
Potential embargoes
Political stability
Expanded cross-cultural challenges

Conclusion

Modularization today is key to meeting major capital program delivery. Increasingly, modularization has grown to be a valued component of large complex project execution strategy. Its utilization and acceptance across a wide range of industries and owners requires that owners and program managers more fully understand modularization's possibilities, the key decision factors involved, and the special risks entailed.

References

1. "A Great LEAP—Modularization as a Strategy," Construction Users Roundtable (Bob Prieto presenting with Gary Chanko); November 2008.
2. "A Great LEAP: Modularization as a Strategy," Gary Chanko and Bob Prieto, co-authors, *The Project Management Standard*, A Quarterly Publication of the Project Management Institute® Design • Procurement • Construction SIG; Vol. XVI, Issue No. 3, Third Qtr., 2009.

For Further Reading

Executive Insight, Importance of Strategic Business Objectives
Executive Insight, Business Basis of Design
Executive Insight, Systemic Risks in Large Complex Projects

Executive Insight, Location Factors in Large Complex Projects
Executive Insight, Procurement Management in Large Complex Programs
Executive Insight, Coupling in Large Complex Projects
Executive Insight, Strategic Program Management of Giga Projects
Executive Insight, Knowledge Management
Executive Insight, Stakeholder Engagement
Executive Insight, Addressing Emergent Risks
Executive Insight, White Space Risks
Executive Insights, Flows in Large Complex Projects

About the Author

Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.