Role of Functional Organization in Large Engineering and Construction Programs [1, 2]

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Large corporate organizations typically employ some form of matrix organization to ensure a consistent approach in key areas across the organization. The nature and extent of this matrix or functional organization will be driven by:

- common approaches to human resources
- consistent application of legal approvals and reviews of significant actions
- common financial functions related to accounting, cash management, insurance and claims & suits
- common managerial, technical and support functions which accrue benefits from a consistent and coordinated approach

Within a project setting, required resources generally reside at the project level and corporate functional activities extend into the project environment only to the extent required to protect the parent organization, consistent with client requirements and practices.

The situation in large programs, however, is different and a functional organization more akin to the corporate functional organization is often created within the program team. This program level functional organization acts much in the same way as the corporate functional organization but its role and emphasis evolves throughout the programs life.

A typical program management organization will include a functional organization that will provide people, management processes, program-level project control tools, and systems. The program management team will thereby bring enhanced management, quality control, efficiency, and coordination to the entire program.

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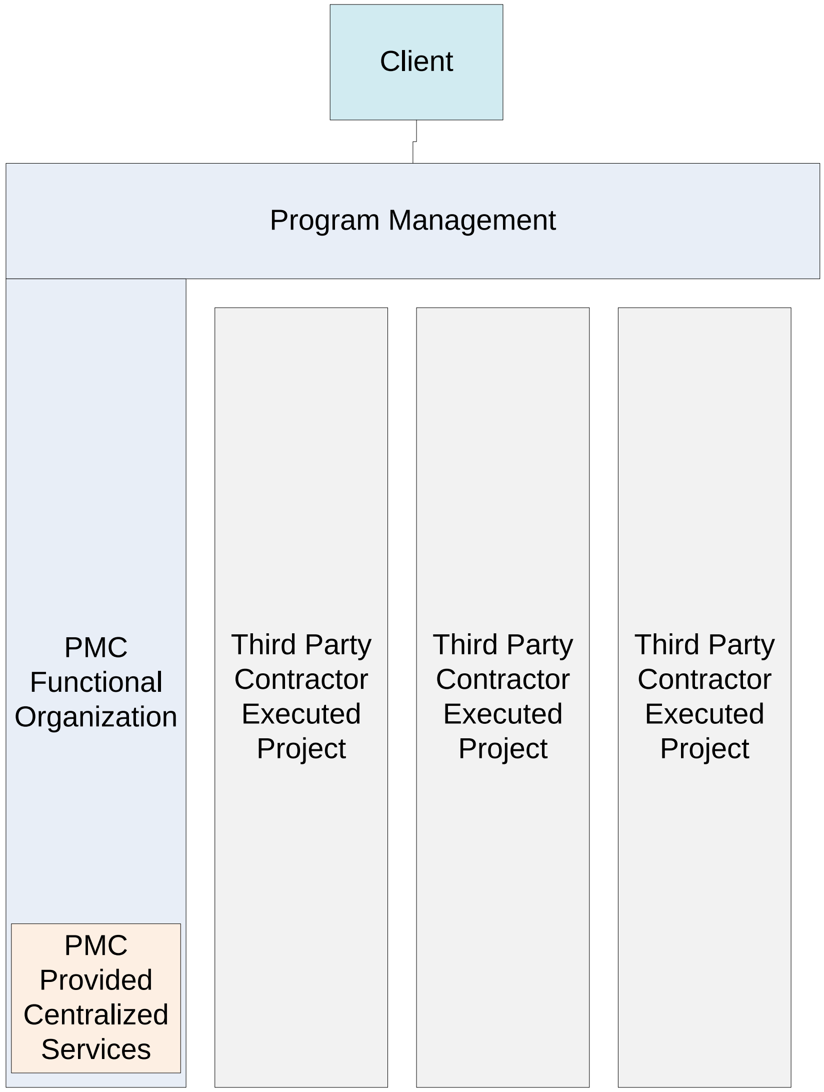


Conceptually, the program management organization might consist of the following major project execution elements:

- Program management
- Business and Administration Management
- HSE and security
- Human resources
- Project controls
- Estimating
- Procurement
- Material Management
- Contracting

- Interface management
- Risk management
- Information technology (IT)
- Quality
- Engineering management
- Construction management
- Program management systems and tools

The larger functional organization will be carefully tailored to cover the "white space" between projects and provide the coordination to harmonize the overall program. The efforts of this team will be critical to a smooth start and overall efficiency. The transition from a larger functional effort to put program standards, tools and processes in place, to a more limited functional organization ensuring consistency of approach across the project-based elements must be understood.

As the program standards, procedures and processes are established, the functional organization will transition into a training, standards enforcement and program audit role. Certain functional elements may adopt a centralized services role providing discrete services across multiple projects comprising the program effort. These centralized service roles should not be confused with the functional roles which are required for standards development and enforcement to achieve program consistency and efficiency and will vary based on project contracting approaches and whether the PMC is also undertaking a PMC^+ role (a role including some project execution responsibilities in addition to the program management responsibilities of the PMC).

In the next sections we will look at three key functional organizations on large engineering and construction programs in more detail:

- Engineering
- Procurement
- Construction

Engineering Management in Large Engineering & Construction Management Programs Utilizing a Program Management Approach

Effective program management requires strong, functional coordination across the various projects which comprise the program. Among those functions in large engineering and construction programs is engineering management. Distinction is drawn between the engineering function and its associated management within each specific project and the program wide management of all engineering activities associated with a program. This later role is the exclusive purview of the program manager. The added engineering role associated with the program manager also assuming a PMC^+ role is not covered here in that these added responsibilities are more akin to those associated with traditional project execution.

Roles and Responsibilities of the Engineering Management Function

The engineering management function implemented under program management has a changed role and responsibilities from that found in engineering execution at the project level and can be broadly characterized as:

- Supporting project selection
- Project baseline definition
- Engineering standards
- Project execution plan approval
- Quality and "fit for function" reviews
- Configuration and interface management
- Change control
- Value improvement
- Technical acceptance of the work
- Program documentation of systems, structures and components

In this role, engineering management is continuously maintaining a program wide perspective looking for:

- Interfaces between projects
- Potential interferences between projects
- Opportunities across projects, such as those from standardization
- Execution efficiency opportunities available from global work share approaches
- Construction efficiency gains from modularization or criteria to simplify or standardize means and methods
- Common risk factors shared by multiple projects
- Risks created in one project by another either in ultimate operation or during construction
- Safety hazards or opportunities shared by multiple projects
- Safety hazards created in one project either in ultimate operation or during construction
- Multiple project procurement opportunities created by standardization or commonality of certain bulk items

This program wide perspective will often drive the engineering manager to recommend project scopes different than what one might find if a particular project was being done in isolation. In addition recommendations by engineering management may change the scope of procurement and materials management activities undertaken by the program manager. Each of these considerations will influence overall program cost, risk level and allocation of risk.

Let's look at some of these engineering management roles and responsibilities in more detail.

Supporting Project Selection

As discussed previously, objective project selection is a key attribute of successful program management. Objective project selection begins with consideration of sets of candidate projects that together would comprise a project portfolio that will meet the established Strategic Business Objectives. Candidate projects must be adequately defined at this early stage and interdependencies identified. Even at this earliest stage, potential projects should reflect the program wide perspectives described above.

Engineering management will develop project profiles for candidate project and these profiles may include mutually exclusive projects. For example project profiles for a cooling tower and once through ocean cooling water may be developed but potential project portfolios would only include one of these projects.

A key aspect of the project profiles created at this stage is adequately recognizing uncertainties and risk drivers.

Project Baseline Definition

After completion of project selection, individual projects must be defined in sufficient detail to allow a program baseline to be prepared. Overall program execution will be measured against this baseline and engineering management's input is a key element in scope, cost, schedule and risk elements of this program baseline.

Individual project baselines prepared at this stage will be of sufficient detail to allow third party contractors, managed by the program manager, to be engaged. Project scopes will reflect some of the initial program wide thinking described above such as increased use of client furnished materials (CFM).

Project profiles prepared to support project selection will be further developed at this stage and engineering standards to be prepared for the program identified. Certain value improvement processes may begin at this stage.

Engineering Standards

Program wide engineering standards will be developed by engineering management and flowed down to project contractors directly or indirectly through the executed contracts. Once engineering standards have been developed and issued by engineering management, changes to them will be tightly controlled and limited recognizing the cost and schedule impacts associated with such changes.

Engineering management will assure that third party contractors have the latest standards, clearly understand them, provide training as required and assure compliance. This teaching and policing role is characteristic of engineering management functions embedded in a program management team.

Engineering standards may include technical and design standards; engineering qualification standards; work process standards; quality control and assurance standards; safety standards; sustainability and security standards; technology standards; and engineering documentation requirements.

Project Execution Plan Approval

Project execution plans will be prepared by each of the third party contractors engaged to undertake a particular project. These execution plans will afford engineering management an opportunity to assess the contractor's:

- Understanding of the scope of work
- Intent to conform with designated engineering standards
- Quality processes
- Conformance with and schedule adequacy of required reviews
- Identification and monitoring of project level interfaces
- Understanding of operating phase safety, operations and maintenance factors
- Plan of work's ability to support early procurement and other critical path opportunities
- Management strategies for top risks
- Early identification of value improving opportunities

Quality and "Fit for Function" Reviews

One of the "policing" challenges faced by engineering management is scope creep. Scope creep in a large engineering and construction program may come in many forms including:

- Design "development"
- "Safety" related changes (which go beyond the actual safety requirement in scope or extent)
- Owner (especially operations) "wants" versus needs
- Broad incorporation of "lessons learned" or "best practices" without careful consideration

At each stage of the project's development, the program's engineering management function must ensure that a "fit for function" perspective is maintained. This should be a prime element in the normal engineering review and quality processes.

In a program context, one project's addition of features other than those required to be "fit for function" may have a ripple effect affecting not only other projects but maybe even overall program performance. For example a decision on one project to relocate an operating staff lunch room and changing area to improve convenience put it into a hazard area for an extreme safety event at another project. Either the facility would have to be hardened, a shield wall constructed or the other project significantly redesigned to accommodate this "want".

Configuration and Interface Management

Configuration Management is the process by which the technical baseline for structures, systems, and components are identified, documented, tracked, and managed. Configuration Management establishes consistency among requirements, documentation and physical configuration, and maintains this consistency throughout the life-cycle, particularly as changes are made. CM also ensures the systematic evaluation, coordination, disposition, documentation, implementation, and verification of all changes, and their impact on the technical baseline. Configuration management is a core role of the engineering management function under a program management delivery approach.

Configuration management within individual projects may be assigned to the individual project contractors with key interface and control points subject to management by the engineering management function of the program manager. Configuration Management is typically implemented through five basic program elements:

- Program Management processes, procedures and contractual documents including:
  - Program management manual (as applicable)
  - Program procedures manual
  - Program execution plan (as applicable)
  - Project execution plans
- Scope, design requirements, program specifications
- Quality Assessment, audit and other quality processes
- Change Control Process
- Document Control

Configuration Management begins once the functional requirements and technical baseline have been established at Project design initiation, and may begin at a higher level by the engineering management function on a program wide basis even before project contractors are engaged.

Configuration Management continues through preliminary design, final design, construction, start-up, operation, maintenance and closeout.

Examples of configuration management documents are shown in the following table.

Typical Configuration Management Documents		
Drawings	**System Descriptions**	**Design, Procurement & Installation Specifications**
Plant layout, area, or general arrangement drawings	**Design Criteria**	**Design Baseline Analyses**
Process flow diagrams		
Fluid system flow diagrams	Functional Requirements Document	Seismic
Piping and instrument drawings	Conceptual Design Report	Hydraulic
Logic diagrams	Design Criteria Package	Thermal (including HVAC)
Utility drawings		Stress
Isometric drawings		Transient
Hanger and support details	**Procedures**	Flooding
Vendor drawings		Emergency generator loading
Anchor, embed, and rebar details	Utility engineering practices, procedures, and standards	Cable raceway routing and loading analyses
Equipment location drawings	Surveillance test and inspection (e.g.Non-Destructive Test)	Breaker coordination
Instrument location drawings	Operating and maintenance	Environmental and seismic qualification
Architectural drawings	Emergency and off-normal conditions	System interactions
Security drawings	Construction inspections and tests	Code design reports
Fire barrier drawings	Acceptance criteria	
Fire zone drawings	Inspection procedures	**3D/4D BIM Model**

Change Control

There are several essential steps in change control:

- identifying and documenting proposed changes
- evaluating the proposed change for value improvement but with a continuing “fit for function” perspective
- assessing configuration management impacts on both a project and a program wide basis
- reviewing and approving proposed changes
- ensuring the proposed change is authorized at the appropriate management level
- implementing approved changes

- ensuring physical configuration and all related technical baseline documentation is updated.

Changes have impacts well beyond changed quantities of materials and additional engineering manhours. These must be taken into account in the evaluation of change proposals and include:

- Disruption impacts including:
  - Equipment modifications delaying delivery of critical path equipment
  - Changed construction sequencing reducing effective productivity
  - Emergence of new constraints
  - Changed risk profile
- Impact on facility operations and maintenance
- Impacts on construction safety
- Impacts on facility safety
- Impacts on sustainability objectives
- Regulatory or licensing impacts

Engineering management has a central role in the change control process.

Value Improvement

Value improvement is a key role of the engineering management function. In this role engineering management should be driving projects to implement strong value improvement programs while at the same time identifying such opportunities of a program wide basis. Examples of commonly accepted value improvement processes to be implemented are reflected in the following table.

IPA Value Improvement Processes
Technology Selection
Classes of Plant Quality
Standards & Specifications
Design to Capacity
Process Simplification
Energy Optimization
Constructability
Value Engineering
Reliability Modeling
Waste Minimization

Predictive Maintenance
3D -CADD

Best practice includes consideration of other value improving processes such as Alignment, Sustainability, Systems Integration Planning, Startup, Operational Readiness Planning, Human Factors Analysis, Plot Plan Optimization, Life Cycle Analysis and Workface Planning.

Technical Acceptance of the Work

Engineering management should conduct in-process reviews against formalized checklists which map to final project and deliverable acceptance criteria. Acceptance criteria should be included in contract documentation and any supporting audit or acceptance criteria shared with the project contractor at the earliest stages.

A key area of focus is to ensure that acceptance criteria and any associated testing regimes or equipment has been previously agreed to. Improving sensitivities in test equipment may result in non-conformances otherwise acceptable based on previous industry inspection protocols.

Program Documentation of Systems, Structures and Components

Engineering management should ensure that all project related documentation across the program has been developed in a manner that supports acceptance testing, commissioning, startup and ultimate facility operation and maintenance. Attention must be given to ensuring that interfaces to systems, structures and components delivered by other project contractors are clearly identified and interface requirements sufficiently detailed.

Associated hazard identification and descriptions should be clear and well developed.

Increasingly large programs are being developed in a 3D/4D environment and delivery of the 3D/4D BIM model is increasingly a project deliverable and all electronic deliverables are gaining preference in large programs.

Programmatic Impact of Change

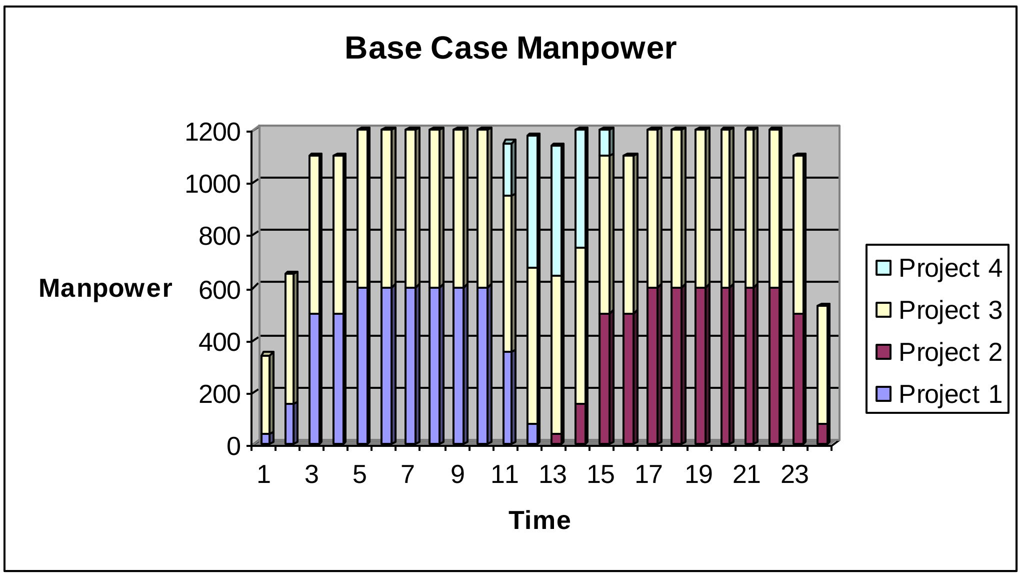
The impact of change can be illustrated in this simple four project program:

- Project 1 is an enabling project, not on the critical path. It has twelve month duration and because of sequencing constraints does not lend itself to acceleration.
- Project 2 is interdependent with Project 1 and can not be initiated until Project 1 is substantively complete. The baseline plan showed it as not starting until after

Project 1 is complete but it could have been started two months earlier since Project 1 is substantively complete.

- Project 3 represents the critical path efforts and project labor on this project element is constrained at 600 as a condition of permitting.
- Project 4 is seasonal related work which cannot be rescheduled but is generally independent of other project linkages except constraints related to overall labor availability.
- Total labor available to all project programs in any period is capped at 1200 as labor is in short supply and multi-owner labor agreements have been executed to eliminate poaching and an uncontrolled wage spiral.

The planned manpower loading is as shown.

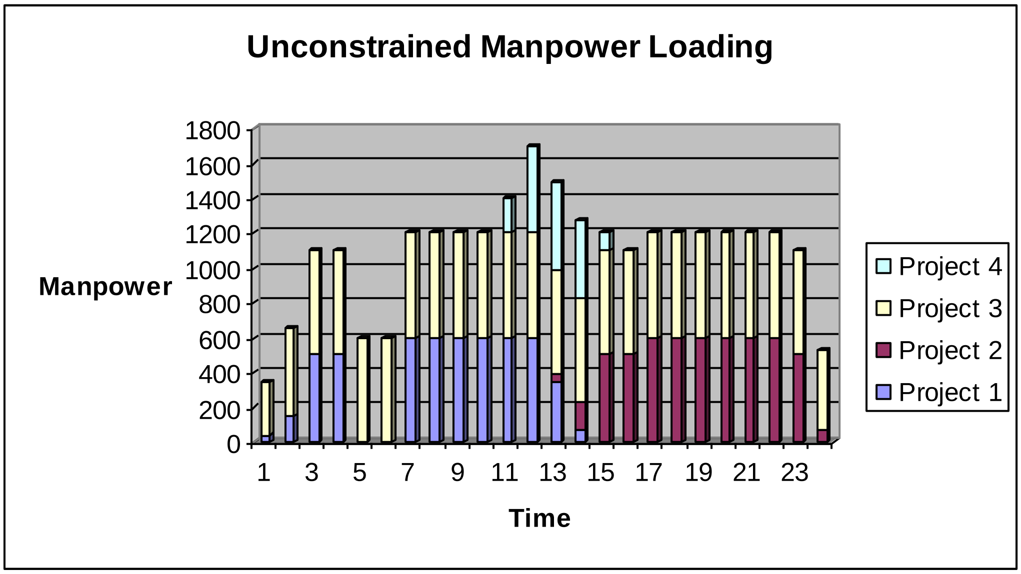


Subsequent to program initiation a change is identified in Project 1 that will cause a suspension in construction and other related activities at the end of month four. This hiatus will last for two months, but Project 1 is not on the critical path and the Project Manager has indicated he can control costs so there is no cost increase and no increased labor requirement, although the project schedule will be two months longer.

The Project Manager for Project 2 is consulted and indicated that he could accommodate a two month slippage in Project 1 since the precedent work he required would be completed in time for him to begin. From a "direct" project interface perspective neither Projects 3 nor 4 were dependent on Project 1.

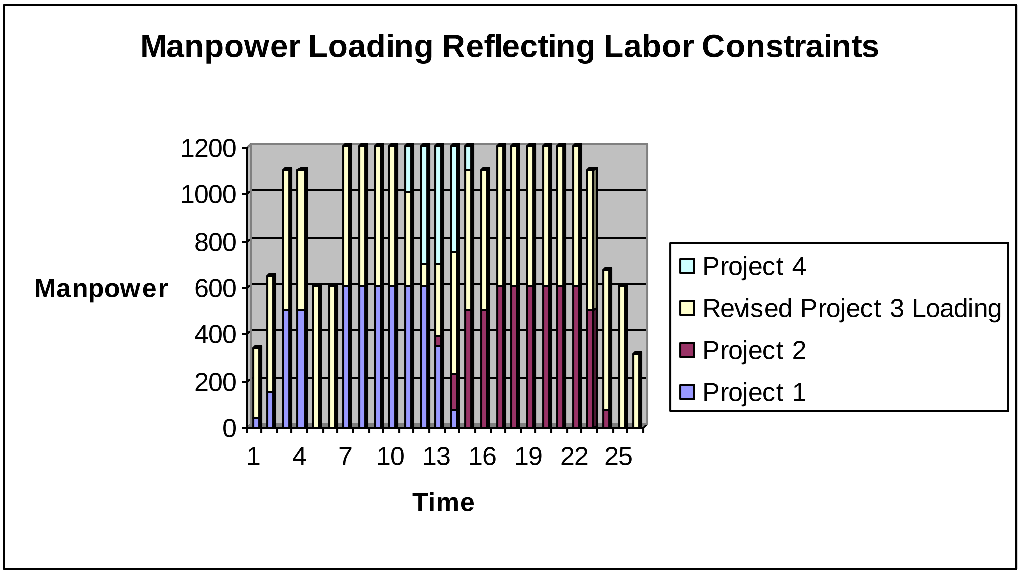
The various Program Management elements need to look deeper than just "direct" interfaces and to some of the constraints which exist in the "white space" between projects or at a program level.

As a first step in that direction the revised manpower loading in an unconstrained scenario is identified.



This initial look shows the overall critical path end date being maintained but only with manpower loading in excess of the overall 1200 constraint placed on the program. Without such a programmatic viewpoint it may not be self evident that the change proposed for Project 1 would cause the program to violate one of its constraints.

Attention now turns to executing the changed program while still meeting both the overall program 1200 person constraint and Project 3's 600 person constraint. This loading shows that program completion is delayed by two months despite the fact that Project 1 is not on the critical path.



Admittedly the example is simple but the point is not. Programmatic impacts from even the most innocuous changes must be fully considered before change is approved.

Strategies for Controlling the Impacts of Change

Change is inevitable or so it would seem. But it does not need to be uncontrollable in large programs. Strengthened and rigorously enforced change management processes and procedures provide a solid first line of defense but more can be done. Some strategies that can be employed by the program manager include:

- Broadening the scope of change impact assessment to go beyond a singular benefit – cost comparison to include a more complete cost benefit comparison that addresses:
    - All potential benefits – these include all benefits program wide considered in the project selection process. Specifically benefits created in other projects and at the program level would be considered. These will include benefits beyond first delivery of the program and would include operating and maintenance benefits, safety benefits both in first delivery of the program and the operating phase, and a full range of sustainability benefits.
    - All potential impacts – these include all impacts program wide including both direct impacts as well as indirect impacts because of changed profiles in constraining factors.
    - Benefits and impacts of not making the recommended change (do nothing option)

- Design freeze as of the time of program authorization for implementation. Under this approach only legally imposed changes are addressed and all other changes are rejected more or less out of hand.
    - The weakness in this approach is that changes that might ultimately be desirable may be lost or never surfaced.
- Modified design freeze where changes undergo the normal change management process but then are further evaluated as to when such changes are to be made. This timing evaluation allows a finer assessment of the impact of change with an eye towards minimizing it while maintaining a "fit for function" perspective. Allowable implementation timeframes could include:
    - Normal project sequence – where the timing for implementation of the change does not require reconfiguration of ongoing activities or the addition of impacting precedent activities
    - Modified project sequence – where the implementation of the change requires precursor activities to be modified as well as potentially subsequent activities. This type of change implementation has the greatest impact typically
    - Deferral to punch list or commissioning stage – schedules typically provide an abbreviated period to address punch list items and some changes may be deferred to this stage without impacting startup and commissioning. Alternately, change implementation may be part of the commissioning process. Any premium associated with deferral must be weighed against the impacts of disruption that might otherwise be incurred.
    - Deferral to post operating – many changes reflect improvements that enhance operating aspects of the program but are not essential for meeting its "fit for function" test. These changes may be better incorporated during the post initial operation phase. Premiums associated with this approach must be weighed against the impacts of disruption that might otherwise be incurred.

Procurement Management in Large Engineering & Construction Management Programs Utilizing a Program Management Approach

Procurement in a program management organization represents a focused effort to improve overall program capital efficiency by seeking to capture the opportunities of leverage embedded in the program scale, simplify market complexities and risks by increasing their visibility and enhancing management of programmatic supply risks by creating opportunities to utilize risk mitigation strategies not available at the project level.

Risks facing large engineering & construction programs include:

- New global sources of supply
- Increased use of module fabrication facilities
- Growing multi-country risk
- Increased competition for essential construction materials
- Constrained shop capacity for select equipment
- Broadened set of financial risks
- Common cost drivers across multiple categories of supply
- Increased importance of current supplier risk performance assessment
- Export compliance risks
- Corruption risks
- Increasing complexity of products and services
- Increased financial volatility
- Increasingly global labor markets
- Rising energy prices
- Shifting industry structures
- Exposure to a growing number of regulatory environments

To address these challenges Procurement in program management organizations has available a wide range of strategies which, while applicable in large project settings, provide added benefits in large programs. These strategies include:

- Supplier Relationship Agreements
- Global Sourcing
- Client Furnished Material (CFM)
- Bulk Material CFM
- Material Management
- Alternative Contracting Strategies
- Logistics Management

Supplier Relationship Agreements

A programmatic approach facilitates the development of supplier relationship agreements with quality suppliers with the capacity to competitively meet the program's needs. The formulation of these supplier agreements allows the program to build a partnership arrangement that brings the procurement activity and critical vendor input forward in the overall program cycle.

Value adding inputs from these strategic suppliers can influence design decisions with an eye towards reducing overall costs and schedules. Procurement cycles are reduced or eliminated for releases after the initial agreement is put in place and quality inspection activities can be more targeted for better results.

Supplier relationship agreements:

- Are pre-priced and pre-negotiated agreements with key suppliers
- Provides volume-leveraged pricing from suppliers who maintain high quality and performance
- Reduce risk profiles through improved supplier performance and cost certainty
    - positive impacts on contingency, warranty, schedule float and product quality.

Global Sourcing

Procurement activities in these programs must be global in scope recognizing market limitations; differential market pricing opportunities; differential financing and financial risks including foreign exchange and sovereign risks; alternative delivery opportunities created by the use of client furnished materials (discussed below); and potential counter-trade requirements.

Global sourcing requires the program manager to have an understanding of the unique requirements and risks associated with each supply jurisdiction. It would not be uncommon for a large program to have primary or secondary sourcing from 50 to 100 countries.

Global sourcing requires a clear understanding of logistics involved; trade and other customs regulations; visa limitations affecting inspection activities; export control regulations; embargo considerations; clearing and quarantine times; required documentation; and fees.

Particular attention must be paid to any increased susceptibility to corruption as a result of this sourcing approach and ensure processes are in place to insulate the program.

Client Furnished Material (CFM)

Client furnished materials in large engineering programs may include:

- Engineered materials, such as major and minor equipment
- Pre-fabricated or pre-assembled materials
- Bulk materials

In general, the use of CFM provides the program with increased opportunities to manage the challenges of scale and complexity while capturing some of the opportunities of leverage inherent in large engineering and construction programs utilizing a program management approach.

Engineered Materials

Engineered materials have been traditionally considered as an area for use of CFM especially as it relates to major equipment, particularly specialized process oriented equipment with long lead times and central to overall program performance. Major equipment on large programs may involve purchases of multiple such units and as such may lend itself to the use of Supplier Relationship Agreements as previously discussed.

Standardization of major equipment provides benefits for ultimate operations as operators may be trained on units completed in early phases of the program. Similarly construction erection methodologies may build upon prior learning experiences to drive towards a best practice as the program is built out.

Newer in its application is the use of CFM for major portions of minor equipment comprising the program. Minor equipment may include items such as pumps, valves and controllers, motors, switchgear and other program components which are uniquely tagged but not necessarily long lead in nature. The principle drivers for the use of CFM for minor equipment include:

- Standardization of components for operations and maintenance
- Reduced program level spare requirements
- Increased inter-changeability of components
- Consistency of quality acceptance criteria
- Improved installation guidelines and protocols
- Reduced contractor risk and contingency
- Leverage from consolidated procurement

Pre-Fabricated or Pre-Assembled Materials

The increase use of pre-fabricated or pre-assembled materials is characteristic of many large programs where either absolute labor constraints exist or site logistics otherwise constrains the ability to undertake all construction and fabrication activities at the site. Benefits include:

- Reduction in program duration
- Improved productivity through transition from a stick built to a manufacturing approach
- Reduced field labor and associated costs (camps, ancillary facilities, other labor premiums)
- Reduced risk through better defined and controlled work processes
- Improved safety by reduced work at heights

This pre-fabrication activity may cover all major disciplines and trades and include:

- Concrete decks and wall sections
- Steel plate structures
- Rebar cages
- Steel struts or other structural steel members
- Mechanical equipment units such as pumps, compressors, heat exchangers
- Pipe racks
- Control rooms
- Switchgear, distribution rooms and other electrical sub-assemblies
- Sampling stations
- Minor buildings
- Major buildings or portions thereof
- Complete process units

Bulk Materials

An alternative approach is for the Program Manager to manage the majority of the bulk material requirements for the program including:

- Identification
- Bid
- Purchase
- Expedite
- Inspect
- Transport
- Receive
- warehouse
- issue to construction

This approach:

- leverages spend across projects
- provides efficient management of surplus materials
- reduces waste streams on a program wide basis
- prioritizes allocation of scarce materials for program advantage
- improves material quality control
- identifies material quantities from engineering at an earlier stage
    - not required to be allocated to projects or contract packages
- reduces program wide inventories and storage requirements
- improves site logistics
- facilitates a structured approach to material substitution

Material Management

Material management activities at the site include all those activities required to receive, accept, store, maintain, control, disburse, track and document client furnished materials to be provided to project contractors. These activities include:

- Complete warehousing activities, inclusive of material receiving and distribution
- Inspection during receiving
- Preparation of overage, shortage or damage reports
- Inventory management and control
- In-storage preventive maintenance
    - Specific requirements for preservation and maintenance of client furnished equipment and materials will be identified in conjunction with suppliers during the initial engineering phase of the program
    - construction equipment provided as CFM will be maintained in accordance with manufacturers recommendations
- Storage based on classification:
    - Outdoor storage permitted
    - Indoor storage only
    - Protected outdoor storage
- Material control planning
- Back charges to suppliers
- Site procurement of miscellaneous materials
- Security

Utilization of robust material tracking techniques such as RFID tags and bar codes would be expected and well developed material management processes and tools are essential. The success of programmatic procurement strategies will very much rest on the ability to meet commitments to project contractors.

Alternative Contracting Strategies

Large scale programs open up new opportunities to improve program capital efficiency as well as shorten overall program schedules. Achievement of these benefits may result in alternative contracting strategies being deployed that can span a wide range.

Programs may employ more than one procurement strategy at a time and the mix of strategies may vary over the lifetime of the program. Examples of some alternative contracting strategies can include:

- Supplier Relationship Agreements for major equipment to be installed by others
- Supplier Relationship Agreements for minor equipment to be treated as free issue material (client furnished material or CFM) to project contractors
- Supplier Relationship Agreements for bulk materials to be treated as CFM

- Supplier Relationship Agreements for select program services such as heavy marine transport; customs clearance; sitewide medical services
- Engineer, Procure, Construction Manage or EPCM contracts with or without incentives
- Engineer, Procure, Construct or EPC contracts with or without incentives
- Engineer, Procure or EP contracts
- Engineering only contracts
- "Horizontal" or program wide construction contracts such as:
    - Site grading
    - Offsites and utilities
    - Master electrical contractor
    - Master automation and controls contractor
- Equipment leasing and maintenance contracts
- Concrete batch plant
- Non process infrastructure and other enabling works contracts
    - Mancamps
    - Commissary
    - Fueling services
- Public Private Partnership or other life-cycle contracts that provide a delivered service versus just an asset. These contracts may extend into the program's operations and maintenance phase.
- Capacity building contracts to meet local sustainability objectives
- Independent inspection and monitoring contracts

Logistics Management

Logistics management begins by developing a plan that addresses specific program conditions and needs. These needs may differ for the various project sites that comprise the program and the logistics management plan will also need to consider logistical issues associated with major supplier locations, shipping and other transportation links, as well as any intermediate work locations such as those associated with pre-fabrication, pre-assembly or full modularization.

Elements of the program that represent logistical complexity or risk must be identified at the earliest stage. Logistical constraints must be clearly identified at each shipping and receiving location and can include:

- Maritime
    - Maximum draft
    - Handling capacity limitations
    - Available transport capacity
    - Demurrage costs
    - Operating rules
    - Cargo limitations

    - Seasonal or heavy weather limitations
    - Flagging
    - Customs or quarantine related issues

- Railroad
    - Route limitations
    - Dimensional limitations
    - Hours of operation
    - Work rules

- Road
    - Transit hours
    - Dimensional limits
        - Height
        - Width
        - length
    - Restricted cargo
    - Local restrictions
    - Maximum axle loadings
    - Maximum bridge loadings
    - Turnout frequency and availability
    - Police escort

- Marshalling, customs or quarantine storage, and warehousing facilities

Logistical contractors for transportation of abnormal loads can be booked up to a year in advance and proper planning is required to avoid schedule impact.

The program manager must also pay particular attention to the cumulative challenges and opportunities associated with program logistics by evaluating such items as:

- Consolidated multi-project shipping and transport
- Programmatic contracting of heavy marine vessels; railroad locomotives and cars; trucking; and specialized transport vehicles (such as the SPMT's required by large modules) and cranes.
- Conflicting and peak logistics requirements

Materials sourced offshore require special attention for customs, license and freight forwarding services. Examples of such considerations include:

- Duty Exemption Lists
- Freight Forwarding
- National Flag Carriers
- Customs Clearance

- Anti-boycott Laws
- Export Compliance

Management of Construction in Large Engineering & Construction Management Programs Utilizing a Program Management Approach

Execution of construction generally resides with the project or other specialty contractors in large engineering and construction programs. The role of the program manager is to ensure that these construction operations are coordinated, optimized and where possible leveraged for the overall program's benefit.

Large programs offer significant opportunities in each of these areas. The number of construction operations taking place simultaneously is large and one of the objectives in large construction operations is to efficiently open up new construction fronts to allow work wherever possible to occur in parallel rather than in sequence. This same drive occurs in singular projects but its importance and the difficulty to achieving is greater in multi-project programs.

Physical interfaces between projects are the program manager's to control while those within a discrete project are generally the responsibility of the project contractor. These interfaces change throughout the program's life and the program manager must not only deal with these on a real time basis but more importantly anticipate.

But not all interfaces fall into traditional interfaces. Rather they can include interfaces centered around resources and constraints. Examples would include finite labor supply; limits on water; transportation or other site logistics and competition for similar resources and services from a small or constrained supply chain.

Opportunities abound in large construction programs and from the program manager's perspective those lying within the "white space" between projects are his to identify and capture. One such example could be capture of one project's "waste stream" for use by another contractor. An excavation requiring groundwater dewatering could provide water for concrete, dust control or fire suppression.

Other examples could include construction of temporary camp structures, warehouse and other miscellaneous buildings for conversion to permanent operating facilities; program level composting operations to meet final landscaping needs; and recycling of demolished concrete to meet later needs.

The greatest value in the management of construction by the program manager will come from his ability to shift program wide means and methods for overall program leverage. This ability to influence can be thought of as occurring in four broad areas:

- Equipment & facilities
- Labor
- Materials

- Services

Some examples of such program wide means and methods shifts are illustrated in the following table.

Program Manager's Ability to Influence Program Means & Methods	
Equipment & Facilities	Program wide specialized equipment: • Heavy lift • Module transport • Other specialized
	Concrete batch plant
	Rebar bending facilities
	Pre-assembly facilities
	Buried utility chases
	Material handling wharfs
	PMC Module yard
Labor	Master Specialty Contractors: • Electrical • Automation
	Craft training program; site orientation program
	Safety training
	Labor related safety equipment
	On-site first aid and medical facilities
	Labor transportation to the site
Materials	Material management operations for Client Furnished Materials (CFM)
	Scaffolding
	Other re-usable temporary construction
Services	Non Process Infrastructure: • Camps • Commissary • Sanitary facilities • Onsite power • Potable water • Fire suppression • Process water for concrete; washing operations; dust control • Select other services
	Onsite fuel storage and refueling operations
	Site wide disposal & recycling operations
	Small tools

	Vehicle maintenance shop
	Consolidated equipment leasing, training and maintenance (Equipment treated as CFM)
	Common warehouses

References:

1. *Strategic Program Management*; published by the Construction Management Association of America (CMAA); ISBN 978-0-9815612-1-9; July 24, 2008

2. *Topics in Strategic Program Management*; ISBN 978-0-557-52887-5; July 2010

About the Author

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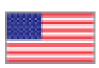

Bob Prieto is a senior executive effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering and construction industries. Currently Bob heads his own management consulting practice, Strategic Program Management LLC. He previously served as a senior vice president of Fluor, one of the largest engineering and construction companies in the world. He focuses on the development and delivery of large, complex projects worldwide and consults with owners across all market sectors in the development of programmatic delivery strategies. He is author of nine books including "Strategic Program Management", "The Giga Factor: Program Management in the Engineering and Construction Industry", "Application of Life Cycle Analysis in the Capital Assets Industry", "Capital Efficiency: Pull All the Levers" and, most recently, "Theory of Management of Large Complex Projects" published by the Construction Management Association of America (CMAA) as well as over 800 other papers and presentations.

Bob is an Independent Member of the Shareholder Committee of Mott MacDonald and a member of the board of Dar al Riyadh. He is a member of the ASCE Industry Leaders Council, National Academy of Construction, a Fellow of the Construction Management Association of America and member of several university departmental and campus advisory boards. Bob served until 2006 as a U.S. presidential appointee to the Asia Pacific Economic Cooperation (APEC) Business Advisory Council (ABAC), working with U.S. and Asia-Pacific business leaders to shape the framework for trade and economic growth. He is a member of the Millenium Challenge Corporation advisory board where he had previously served. He had previously served as both as Chairman of the Engineering and Construction Governors of the World Economic Forum and co-chair of the infrastructure task force formed after September 11th by the New York City Chamber of Commerce. Previously, he served as Chairman at Parsons Brinckerhoff (PB) and a non-executive director of Cardno (ASX)

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