The Gigaprogram Challenge

By Bob Prieto

This issue of PM World Journal challenges writers and readers to consider the planning and management differences between megaprojects and more conventionally sized projects. In this paper I will focus on a subset of these megaprojects which I will refer to as gigaprojects, or more appropriately as "gigaprograms"[1], and encompassing projects with constructed values in excess of $10 billion[2]. I have chosen this subset of projects since I believe that many of the particular challenges we see at this scale and level of complexity exist more broadly in megaprojects but are perhaps not as easily seen.

Readers of PM World Journal and its predecessor publication will recognize that this is a subject that I have written extensively on including several books[3] [4] [5] [6] on this subject area. This paper will focus on a few of the planning and management differences that experience suggests are most significant in influencing project outcomes at this scale.

Gigaprograms vs. Traditional Projects

There is a tendency to think of the essential difference between megaprojects and more traditional sized projects as one of scale. If only it was that simple. A better analogy, and something that we see more clearly in the world of gigaprograms, is that this scaling up in size has the concomitant effect of "unfolding" unseen dimensions that were likely always there but whose effects were not readily noticeable.

These unseen dimensions:

- create new regions of "white space", that if not aggressively managed, serve as nesting and breeding grounds for new, more systemic type risks[7]

[1] In reality endeavors at this scale really reflect the simultaneous execution of a multiplicity of distinct but inter-related projects and thus must be viewed in a program context to fully appreciate the inherent complexity and challenges
[2] The math may not work but conceptually this order of magnitude difference in scale allows us to clearly see opportunities and challenges likely available in megaprojects but not as readily seen
[3] Strategic Program Management; published by the Construction Management Association of America (CMAA); ISBN 978-0-9815612-1-9; July 24, 2008
[4] Topics in Strategic Program Management; ISBN 978-0-557-52887-5; July 2010
[5] The GIGA Factor; Program Management in the Engineering & Construction Industry; CMAA; ISBN 978-1-938014-99-4; 2011
[6] The Program Manager's Role; "Managing Gigaprojects"; Chapter 6; ASCE; 2012; ISBN 978-0-7844-1238-1
[7] These "white spaces" may also act as homes for new, yet to be discovered opportunities, if we only look hard enough and understand the potentials that exist

- expose a subtle "coupling" across the gigaprogram that at smaller scales was not as significant; this "coupling" is not only direct coupling but importantly indirect coupling realized through "coupled constraints" or "white space" couplings that previously were not significant
- drive us to a level of complexity where the scaling of activities is dramatically outweighed by the scaling of the possible network combinations and effects that are created.[8]
- expose the fragility of many of our assumptions, as longer project development and execution periods that are inherent characteristics of commitment of growing levels of capital, demonstrate that they are far from static and instead experience "assumption migration"[9]
- highlight management dimensions that are less significant on smaller scale projects such as those associated with:
    - increased strategic importance (achievement of strategic business objectives or SBOs with their outcomes focus) vs. the output focus of delivering more traditional projects and the emergence of a changed governance regime
    - owner, not just project, readiness given the increased level of owner organizational involvement and oversight that gigaprograms attract
    - increased importance of multi-party contractual relationships both in the various execution teams and potentially even in the project ownership structure
- expose the need to think about "capital efficiency" in a fuller way than is traditionally experienced on smaller projects where CAPEX or construction schedule usually suffice as project optimization points.

[8] We can see this non-linear scaling of complexity if we consider two combinational cases. In the first case, we have 10 activities, which if we consider combinations two at a time results in 45 possible combinations or said differently 45 potential sets of interactions. In the second case we might consider that as result of scaling up of the project tenfold, we have ten times as many activities. In this case, still considering combinations two at a time we arrive at 4950 possible sets of interactions. Even if this scaling up tenfold only resulted in twice as many discrete activities, the number of possible interactions would rise over fourfold to 190 possible interactions.

[9] This "assumption migration" can be thought of simply as the reasonable error band which we may have recognized as existing at project initiation but which broadens as time passes. In a simple case take project escalation which we may have forecasted at 5% +/- 1% at project initiation. If the worst of our initial assumption set materializes we will experience 10% growth above our base estimate in a 10 year project. If this higher level of escalation persists we may find that our assumption may migrate to 6% +/- 1% which, if we experience this new, higher potential rate (7%) from the midpoint of say a ten year schedule would drive our potential overrun even higher to say 15%. In reality, the types of "assumption migration" we are concerned most about are those that demonstrate 2σ or greater behaviors or are particularly sensitive to uncertainty growth when confronted with extended time periods.

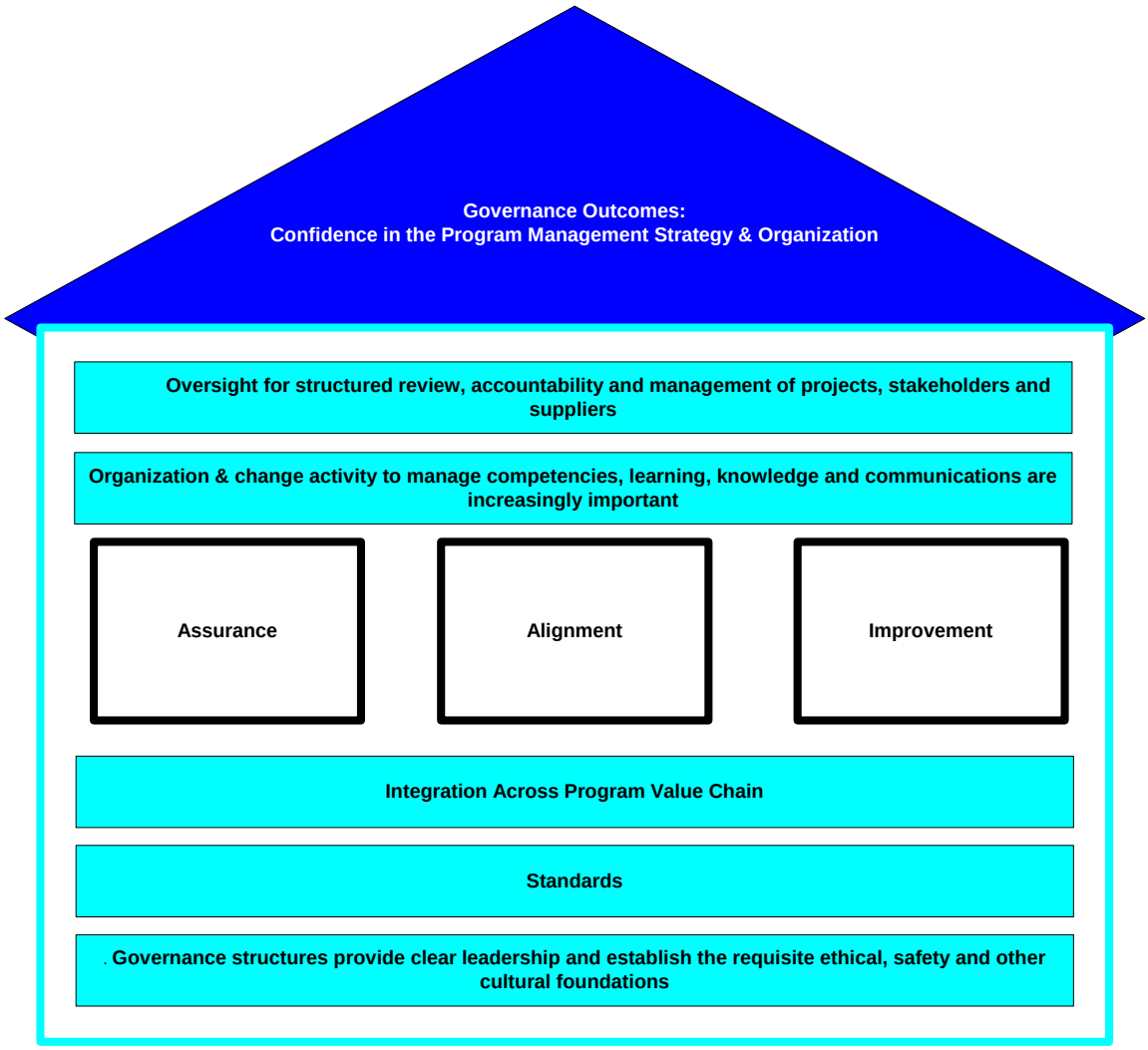
Essential Differences

Let me turn now to some of the essential differences I see and why they are important and why as owners and deliverers of the large scale projects we have much to do. Let's begin at the beginning with the owner's definition, articulation, communication and alignment around the Strategic Business Objectives (SBO) that the program is designed to achieve. In more traditionally sized projects this discussion around SBOs rarely happens, instead replaced with a discussion of the owner's project requirements (OPR). In fairness this is probably sufficient since these smaller projects are often more discrete, more tactical in nature. As we move to larger scales the import of these projects increases and the existential threat their failure or significant under-performance represents grows.

In a career of extensive involvement with so called "gigaprograms", the #1 reason for underperformance is associated with lack of clear articulation and alignment around the program's SBOs.[10]

With SBOs in hand we must now put in place a robust governance structure and process[11] and objectively and carefully define what our program will look like[12], what its constituent projects will include. This is not trivial as the very scaling up of the project and concomitant "unfolding" of the new dimensions previously described creates new options, opportunities and potentially optimization points.

[10] Between 70 – 90% of underperforming projects of scale suffer with this most fundamental lack of alignment which must precede even our more traditional project alignment activities.
[11] Governance: Key to Successful Program Management Delivery; PM World Today; March 2008
[12] Project Selection in Large Engineering Construction Programs Second Edition, Jun 2011 Featured Paper; PM World Journal; December 2013



Projects which jump to a "desired" configuration, over constrain OPR or worse fail to consider the full range of levers that are available to enhance capital efficiency lose focus on the SBOs and fail to:

- maintain focus on strategic business objectives allowing biases to enter the process
- establish a sufficiently strong methodology for project portfolio evaluation, often only considering one primary strategic business objective without attention to other such objectives
- appropriately cascade metrics down to the assessment of project portfolio performance
- adequately reflect uncertainty and risks in portfolio evaluation

In defining our program configuration, developing a comprehensive strategy and translating these into a project execution plan we must remember the particular susceptibility that large scale projects have to the planning fallacy.

Daniel Kahneman's book, "Thinking, Fast and Slow"[13] returned his concept of the "planning fallacy" to the project management center stage when considering large, complex projects and programs. First coined by Kahneman and Amos Tversky in a 1979 paper[14], the planning fallacy[15] is the tendency of people and organizations to underestimate how long a task will take even when they have experience of similar tasks over running.

Reference class forecasting, one method for suspending one's impressions and providing a more critical evaluation of the task at hand, is under utilized in general and on large projects in particular, as the challenges of producing even the "base" plan overwhelm the project team. This approach addresses the natural tendency to underestimate costs, completion times and risks while at the same time overestimating benefits. It squeezes out biases while considering the inevitable "improbable" risks that all projects face such asthe risks that inhabit the "white space" between elements of a program and possibly even the odd "Black Swan" that shows up from time to time.

The Association for the Advancement of Cost Engineering (AACE) has recognized the value of estimate validation using separate empirical-based evaluations to benchmark the base estimate, the equivalent of reference based forecasting. This estimate benchmarking process is widely used in the process industries but need not be constrained to them.

Before diving further into the special or elevated challenges that large scale projects face let's return to the foundations for success which must be in place and which take on changed form or increased import. As we have already seen the owner is faced with added governance challenges and at an even more fundamental and potentially existential level. Project selection, or maybe better said, program design requires deeper and changed optimization points and susceptibility to the planning fallacy grows as does the attendant risk of "assumption migration" previously described. Add to these foundational issues three more:

- owner readiness
- use of collaborations (project ownership and execution)

[13] Thinking, Fast and Slow; Daniel Kahneman; ISBN:9780374275631; 2011
[14] "Prospect theory: An analysis of decisions under risk". Econometrica; Kahneman and Tversky; 1979
[15] Managing the Planning Fallacy in Large, Complex Infrastructure Programs; PM World Journal; August 2013

- decision making frameworks

Owner Readiness

Major projects today often succeed or fail based on the readiness of the owner's organization to undertake those projects. In engaging with owners over the course of multiple large projects it became clear that there are certain elements of readiness which must be in place in order to promote project success. I will suggest that a formal evaluation and scoring by owners may prove to be a useful tool to assess their progress in moving toward project execution. These considerations are separate and distinct from an assessment of the readiness of the project itself. This project development readiness assessment should be similarly conducted utilizing tools such as the Construction Industry Institute's Project Development Readiness Index or PDRI. The Owner's Readiness Index[16] (ORI) is designed to more specifically look at issues within the owner's organization, its processes and level of shared understanding and is structured to consider:

- Owner readiness with respect to an individual program and associated decision frameworks and processes
- Program objectives and criteria
- Program planning and execution approach

Many of the areas of concern previously described will gain attention through use of the ORI and owner's philosophies and various factors around time and money can be clarified before serious efforts are underway.

Use of Collaborations

The use of collaborations in accomplishing strategic business objectives has grown considerably over the years with two thirds of the business leaders in a Bank of America Merrill Lynch research survey indicating that they had worked closely in collaboration with at least one other organization and 90% indicating that the future depends on even more collaboration.

These collaborations are common in large programs and may take various forms and are driven by factors such as:

- Scale
- Complexity

[16] Owner's Readiness Index; PM World Journal; January 2014

- Access to technology or intellectual property
- Satisfying national or local participation goals.

The use of joint ventures (including special purpose vehicle (SPV) and limited liability company (LLC) structures) is a growing practice in the engineering and construction market, driven by the factors above but also by greater use of alternate contracting and project delivery strategies including design build and public private partnerships, common delivery strategies on large scale programs. While these joint venture structures are all established for finite objectives, the durations of many of them exceed the lifetimes of many companies.

A survey[17] suggested that owner side contracting, management and engagement strategies could benefit from a clearer recognition of the added complexity inherent in a JV and development of a more robust set of industry best practices.

From the JV side there is a major opportunity to ensure JV success by having a more robust set of governance documents including full JV agreement and various governance practices and process descriptions available in parallel with teaming agreement development; a clearly defined and robust JV board role defined in the proposal and recognized in the contract with the owner; and the foresight to invest in the "soft factors" of project success. Visibility and discussion and management of those risks uniquely created by the JV nature of the execution team are also essential.

Decision Making Frameworks

It often appears that the risks of delay scale with project size[18]. One way to think about this scaling is that a project's impact is proportional to the length of the fence you would have to put around the area impacted. Large scale programs often have large impact "basins" – whether those impacts are economic, environmental or social in nature. As impact "basins" grow so too does the potential for delay

> ***"Ask of me anything but time"***
>
> ***- Napoleon***

[17] A Look at Joint Ventures; PM World Journal; Vol. II, Issue III – March 2013
[18] Perspective on the Cost of Delayed Decision Making in Large Project Execution; PM World Journal; February 2014

Table 1 lays out some potential causes of delay. Large projects by their very nature require major decisions to be made by owner organizations on a regular basis. A significant driver of cost and schedule growth is often slow or incomplete decision making. In one instance an owner's organization had calculated the value of 1 minute of general delay on a $10 billion project at $14,000 and used that number to guide the maximum time invested in making decisions. The increased number of decisions that large projects require itself necessitates more robust decision making frameworks and greater delegations of authority. In a word, the owner's role must evolve[19]. Table 1 also highlights the importance of nailing down performance requirements (outcomes vs. outputs based) that were highlighted earlier as well as the broader exposure to a set of delay factors largely external to the project itself.

Table 1
Causes of Delay

Timely decision making by owner
Changed owner performance requirements (fit for purpose redefined)
Intentional delay of project driven by business factors (market conditions; competing factors requiring management attention; cash flow or other financial market constraints)
Delayed or withheld regulatory approvals or changed regulatory requirements
Technical challenges not anticipated
Events anywhere in the supply chain broadly impacting progress

Managing the Differences or Managing Differently[20]

Success on this new class of gigaprograms starts by recognizing that the tremendous effort that we traditionally put into defining the "round peg" that we want is not enough. We must put equal energy into defining and "building" the round hole. Together owners, suppliers and contractors must identify those processes and institutional structures which act as barriers to the systemic type innovation which is required on a gigaprogram. Inadequate attention has been paid to "building" the round hole these projects require and addressing the systemic issues[21] which "unfold" with scale.

[19] Evolution of Owners Role Under Program Management; PM World Today; April 2008
[20] Strategic Program Management; Video; April 15, 2009
[21] Systemic Innovation and the Role of Program Management as an Enabler in the Engineering & Construction Industry; PM World Journal; March 2013 Second Edition

This leads us to ask new questions about how we manage and make decisions; how traditional roles change and how they further evolve through the program; how the supply chain is reconfigured and how it evolves through a gigaprogram; and how we create a learning organization across corporate boundaries.

An early and open top level focus on strategy is more important than ever.

But strategy must be matched with superior execution. Tighter integration across all systems is required with this integrated framework acting as an enabler of systemic innovation. Increased visibility of the impacts of change are required as are more systemic approaches to design, procurement and construction. Scaling factors only serve to exacerbate the growing importance of these systemic factors. The limitations of our industry's structure[22] [23] become more apparent as larger scale projects push the boundaries of our tools, mindsets and institutional frameworks.

Increasingly these programs rely on "virtual", vertically integrated teams that include:

- strategy and design teams
- global sourcing operations that include key strategic suppliers as an integral part of this "virtual" team
- construction operations increasingly performed in a manufacturing inspired modular facility.

These vertically integrated teams, focused on improving capital efficiency, may assemble financing, startup and commission the plant, and perhaps operate it on a long term basis. Large scale projects often live in a very different world and successful delivery[24] has some drivers of particular import including:

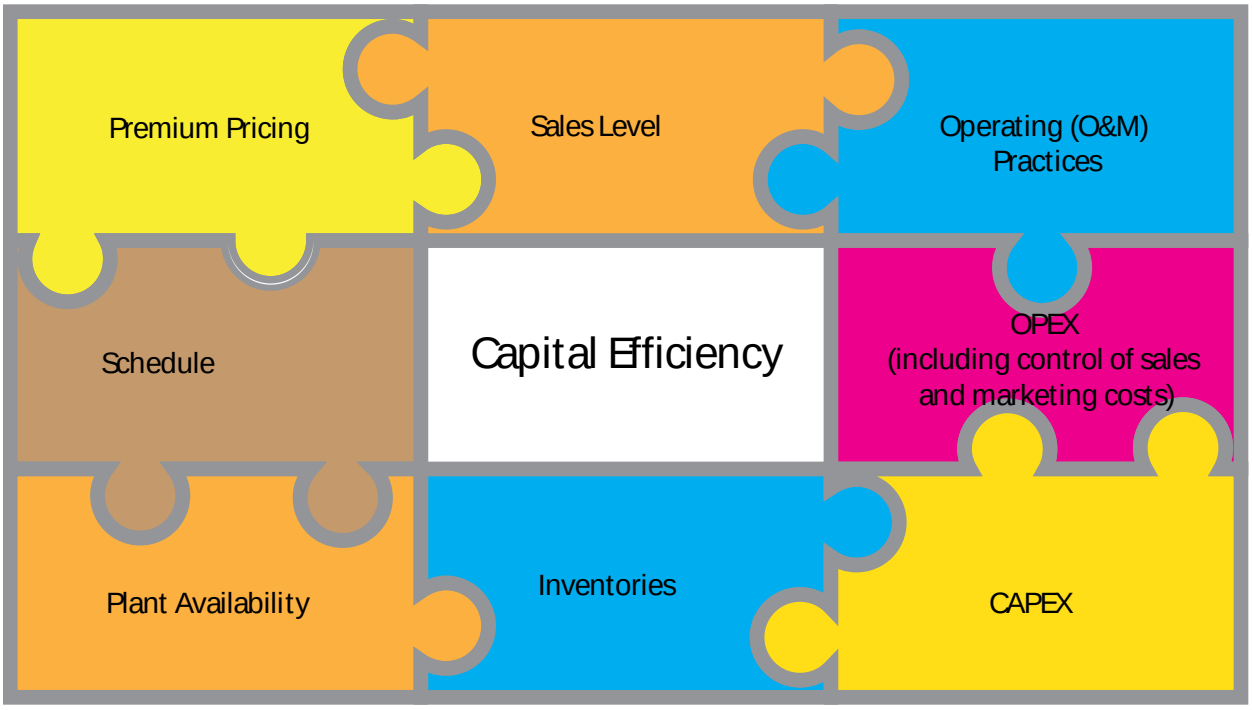
- broadened focus on capital efficiency
- need for an expanded basis of design
- strengthened early and continuing focus on opportunity identification and realization
- changing nature and emergence of correlated risks
- a requirement for continuous alignment, including reaffirmation of SBOs
- clear view on sources of complexity

[22] Fostering Systemic Innovation; E&C Needs a New Business Model; ENR Viewpoint; December 19, 2011
[23] The Engineering & Construction Industry Innovation Deficit: Is the E&C Industry Model Broken?; Stanford University Collaboratory for Research on Global Projects; Working Paper #50; May 2009
[24] Strategic Program Management: Key to "giga" Program Delivery; PM World; July 2009

Broadened Focus on Capital Efficiency

In simplest terms capital efficiency[25] (sometimes referred to as capital intensity) is about getting the biggest bang for the buck. It has become a driving consideration by owner's organizations undertaking large scale projects together with cost and schedule certainty.

Focusing on capital efficiency and the value it can bring drives alignment across all participants in a capital assets life cycle. This includes the owner's project development organization, his EPC, contracts and legal, operations and finance.



Within the EPC organization it drives a fundamental shift in what is designed, how it is designed and the sequence and packaging of design. Through frameworks such as the expanded basis of design, BOD^X, discussed in the next section, we inculcate not only capital efficiency considerations but support a culture of innovation and continuous improvement.

The interplay between each of the eight levers of capital efficiency becomes increasingly important in gigaprograms and as such the early decisions on program design, inherent flexibility, strong stage gate processes and clearly defined SBOs

[25] Capital Efficiency - Pull All the Levers; PM World Journal; Vol. III, Issue V – May 2014

become all the more important. During the engineering and construction of these large scale projects we can influence or impact five of these eight levers. In more traditionally sized projects the ability to influence capital efficiency is typically more narrowly confined to CAPEX and schedule, although exceptions exist. The longer project durations of these megaprojects makes continual awareness of the impact of project decisions on ultimate capital efficiency all the more important.

Expanded Basis of Design[26]

Large capital construction projects are challenged today in three significant ways as outlined in the prior section:

- Capital efficiency – this considers both first costs as well as life cycle costs
- Capital certainty – reflecting execution efficiency, predictability and effective risk transfer through appropriate contracting strategies
- Time to market – perhaps best thought of as schedule certainty but also accelerated delivery of projects often an essential ingredient in capital efficiency

Improvement of capital efficiency in large capital asset projects is possible through the adoption of an expanded basis of design that considers all aspects of a capital asset's life cycle. In effect we want to achieve maximum leverage of the extensive investments we are making over a protracted period of time in these large scale programs. In many projects today the basis of design (BOD) largely encompasses the engineering parameters which are required to meet the owner's project requirements. This narrower view adds to project costs and schedule, increasing their susceptibility to scaling and complexity factors that smaller projects do not face to the same degree. Today's inadequate attention contributes to large project performance issues but also represents a tremendous opportunity area for future projects.

[26] Addressing Project Capital Efficiency through a Business Basis of Design; PM World Journal; April 2014

The unique lifting capabilities of the Left Coast Lifter fundamentally altered design and significantly reduced capital costs on the new Tappan Zee Bridge.

Photo: Left Coast Lifter – SFOBB

"Photograph © Joseph A. Blum"

Today, constructability and maintainability are often treated as review items to confirm that the developed design is both constructible and maintainable and to suggest improvements at the margins. Effective constructability and maintainability reviews add value to the project but do not fundamentally act to shape the design itself in most instances.

More, much more, is required to develop effective designs that are developed with construction and maintenance as fundamental project requirements. In this sense construction and maintenance considerations are not items to be reviewed but rather fundamental requirements to be satisfied together with other project requirements established by the owner. The large scale of these projects often acts to deter the upfront investments required at the project selection and definition stages to capture maximum value although we see good examples of construction driven design in smaller and select larger projects. New tools are required together with a shift in mindset and perspective.

Opportunity Identification and Realization

Large scale programs are faced with significant challenges of scale and complexity. They also offer a wide range of opportunities to better leverage existing and new models, practices and processes. Capturing and capitalizing on these opportunities benefit from a structured and ongoing examination of opportunities much in the same way as risk are systematically identified, assessed and managed.

The opportunities for any specific large scale engineering and construction program are governed by:

- nature of program and its individual projects
- owner related constraints
- site constraints
- market constraints
- supply chain and logistical constraints
- governmental, regulatory and stakeholder constraints
- additional program specific constraints

Large scale projects have an ability to avail themselves of a broader set of opportunities [27] but are often challenged to do so. Successfully exploiting these opportunity areas is essential to offsetting the added risks and challenges that come with scale and complexity.

- Business Model — How to fund the program; maximize return on investment
- Networking — Optimizing the value chain
- Enabling Process — Streamlining owner driven processes
- Core Process — Applying proprietary processes and intellectual property
- Program Performance — Implementing Value Improving Practices
- Program System — Adopting life cycle framework
- Program Teamwork — Adopting strong alignment and partnering approaches
- Outreach — How stakeholders are engaged
- Communication — How program benefits are communicated to stakeholders
- Stakeholder Experience — How positive stakeholder experience is achieved

[27] Opportunity Analysis Under Strategic Program Management; PM World Today; September, 2010

Changing Nature and Emergence of Correlated Risks

Today's major capital construction programs face an emerging set of risks[28] that extend well beyond the project's battery limits. While such over-arching or multi-project risks have existed in the past in the form of regional or national political risks, labor strife or even common exposure to natural events, today's increasingly networked supply chains face new challenges of a scale and consequence rarely seen in the past.

Major capital construction programs are increasingly exposed to emerging risks that are the result of "industrial" style management and governance models which do not adequately reflect the networked nature of delivery of today's mega-construction programs. Tight coupling is creating new risks in large scale projects that is not yet adequately understood or managed and to which more traditionally sized projects are less susceptible to.

Today's large capital construction programs are nothing if not increasingly complex. The management tools of yesterday are increasingly challenged to deal with the growing complexity that is associated with gigaprograms and other large scale projects. But new tools are not enough. New management and governance models must evolve if we are to capture the value of globally networked supply chains and the opportunities for "networked" delivery of major programs that new tools can provide.

Historical command and control models of management, first devised to support repetitive assembly line style, discrete operations do not serve large projects well. Centralized command and control structures are increasingly challenged and persistent micro-management or extended decision making time frames that many large programs experience are a formula for failure.

The management of these large capital construction programs must be more "organic" in nature, with feedback mechanisms helping inform and shape actions throughout what will increasingly be an organic program. New skills will certainly be required or perhaps just a changed emphasis on skills already present. Whatever the right answer is, it still lies ahead. In many ways, this disconnect between management models and project execution opportunities may represent the biggest correlated risk large projects face.

But correlated risks do not tell the whole story of the changed risk profile that large programs face. Traditional scale projects face challenges that largely focus on the management of known knowns and known unknowns.

[28] Evolving Nature of Program Risks in the Engineering & Construction Industry; PM World; September 2008

But large programs by their very nature move into a new neighborhood where previously rare unknown unknowns are more prevalent. In effect, large program risks grow in new non linear ways.

What causes this growth?

Simply put:

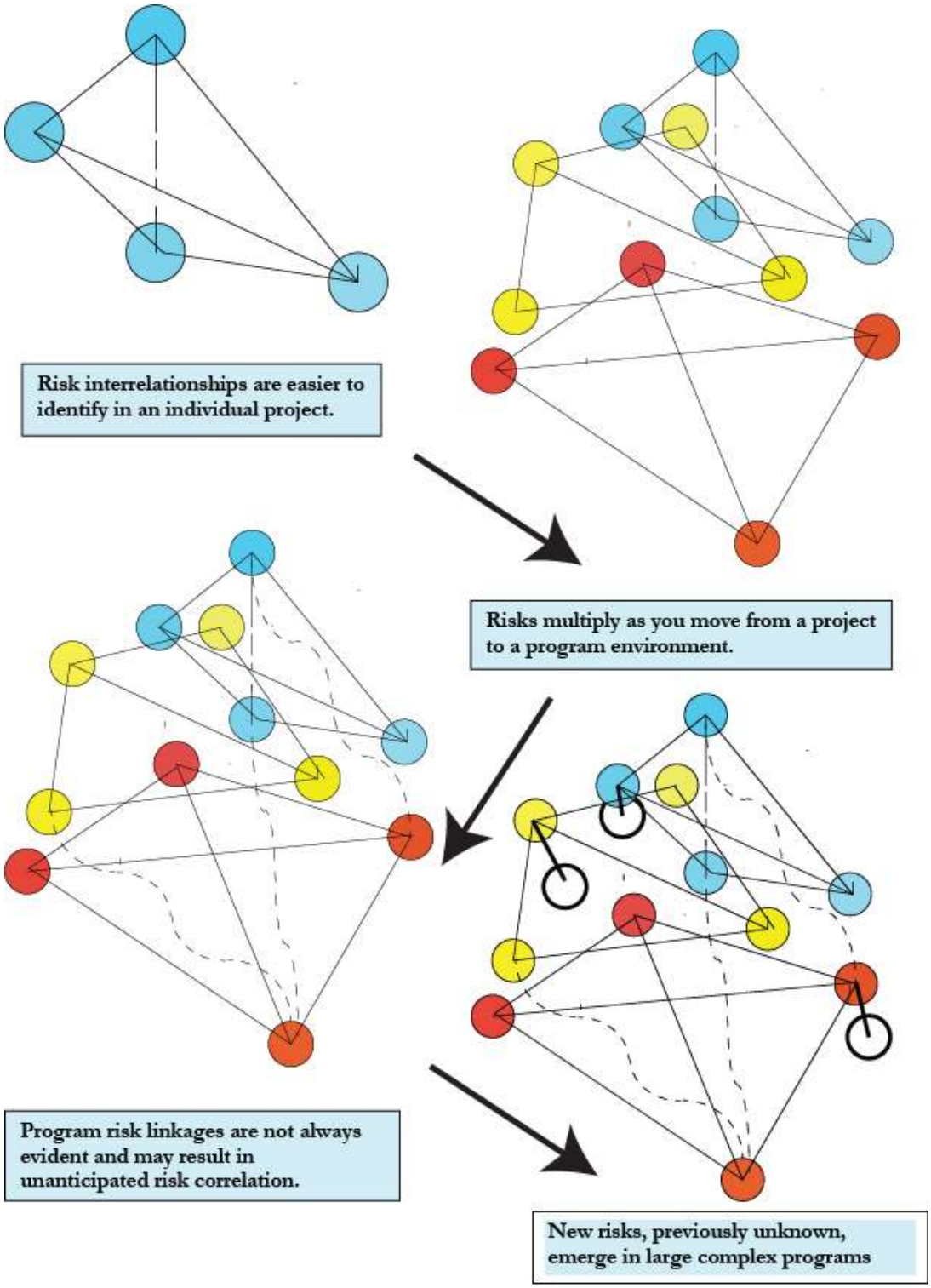
- Scale and complexity move you into a new neighborhood where so called "Black Swans"[29] [30] may be more common
- Scaling drives non linear and non correlated growth in risks
- Complexity masks existing risks
- Complexity creates new risks

Complexity and scale create an attractive environment for Black Swans. They create a hidden, interlocking fragility while at the same time giving a perception of stability in this complex system.

Vulnerabilities enter large programs, project organizations and other human-designed systems as they grow more complex. Increasingly these systems and their myriad of relationships, including hidden relationships, are so complex that they defy a thorough understanding

As complexity grows insufficient attention is often paid to the introduction and proliferation of new links with new risks. As a result, many programs continually implement workarounds and "fixes", which ultimately add to the total life cycle cost and often sow the seeds of new risks and new failures.

[29] "Black Swan" Risks; PM World Today; January,2011
[30] PM World Today Letter to the Editor; February 2011


Risk interrelationships are easier to identify in an individual project.
Risks multiply as you move from a project to a program environment.
Program risk linkages are not always evident and may result in unanticipated risk correlation.
New risks, previously unknown, emerge in large complex programs

Continuous Alignment[31]

As we have already seen, large programs require alignment to be at a much more fundamental level, beginning with articulation, agreement, alignment and continuous communication of the Strategic Business Objectives. But the multiplicity of organizations; the complexity of contracting relationships and interfaces; the use of collaborations; a global supply chain assembled on an ad hoc basis; and the absolute duration of large scale programs makes the normal project alignment challenge exceedingly complex.

When continuous alignment especially around SBOs is inadequate, large programs experience delayed decision making and execution "frictions" which take their toll. This is not to suggest that more traditional scale programs are immune from alignment related issues but rather addressing them is far less complex and project durations typically shorter with more stability of the project teams.

[31] Continuous Alignment in Engineering & Construction Programs Utilizing a Program Management Approach; PM World Today; April 2011

Sources of Complexity

As we have seen, scale and complexity become mutually reinforcing in large programs. New sources of complexity emerge that are not typically encountered in traditional scale programs. Even our traditional focus on metrics fails us when it comes to complexity. How much complexity does a project have? Does it change over time? What are the principle drivers of complexity? How does complexity in one project compare to another? How does complexity in one project execution approach compare to another?

The questions continue but our management of complexity in large scale programs remains challenged. New challenges require new solutions but these have not come fast enough in the world of large projects.

Table 2 highlights some sources of complexity in large engineering and construction programs. Much must be done if we are to improve the performance of these large scale projects.

Table 2
Sources of Complexity in Large Engineering & Construction Programs[32]

Strategic Business Objectives(SBO)	Ambiguity; visibility; lack of alignment
	SBO migration over time
	Conflicting SBOs
	Competitive landscape changes
	Market migration
	Economic susceptibility (local; global)
	Owner complexity (JV; alliance; state owned enterprise)
	Scope/reach of defined outcomes
Organizational	Shared understanding of program management inadequate
	Clarity of roles and responsibilities inadequate
	Resistance to change
	Value destroying processes and procedures
	Lack of sense of urgency
	Stress level; team fatigue
	Silos that impact communication and knowledge sharing

[32] Application of Life Cycle Analysis in the Capital Assets Industry; Construction Management Association of America (CMAA); June 2013; ISBN 978-1-938014-06-2 (eBook); ISBN 978-1-938014-07-9 (Print)

	Cultural issues
	Number of locations
	Distance of program from day-to-day business
	Workshare systems and process experience and effectiveness inadequate
	Duplication of efforts (Owner/PMC)
	Duplication of efforts (PMC/suppliers)
	Risk aversion vs. risk management
Political	Degree of political sensitivity (project or key supply locations)
	Political stability (number of relevant political players; number of election cycles or other anticipated changes of government)
	Role in power struggles
	Sustainability of political will
	Role of supply chain in international relations (enabler or held hostage)
	Extent of capacity building and feedback role
Project Portfolio	Number of projects
	Precedences and interdependencies
	Uncertainties of assumptions and data
	Sophistication of modeling and analysis
	Assumption migration
	Definition of “white space”
	Number of constraints
Program Execution	Cyclomatic complexity
	Structural complexity of program plan, WBS, and schedule
	Degree of shared constraints (first; second; third order)
	Degree of constraint coupling (direct and indirect)
	Number of changes
	Supply chain resiliency; extent of common failure modes (common sub-tier sourcing)
	Depth of labor pool (total and critical skills)
	Labor predictability (labor action; productivity)
	Physical complexity of projects comprising the program (footprint; degree of temporary construction; duration of discrete work activities (duration of transition phases))
	Specialized equipment availability and lead times
	Permitting and regulatory complexity; timeliness

	Logistical congestion and chokepoints
	Flexibility of sequencing
	Financial and financing constraints
	Regulatory constraints
	Management tools and systems not adequately integrated
	Shallow risk management
	Extent of feedback mechanisms
	Distance of projects and key supply locations from day-today operations
Technological	New process
	New tools
	Technical design basis not fixed
	Prototyping, planning, and analysis inadequate
	Specialized materials or skills
	Limited number of suppliers
	IT complexity
	Systems integration extent
Environmental	Extent of regulatory processes
	Number of significant issues
	Effective footprint
	Duration of impacts

Changed Risk Management is Essential

The management of projects in general and large projects in particular is very much about the identification, monitoring and management of risks. As we have seen above the very nature of risks changes in large scale projects. New risks emerge, traditional risks emerge in changed form and character, and importantly a range of systemic factors cause the very nature of the risks we identify to shift over the extended durations characteristic of many of these large programs. This was illustrated in the notion of "assumption migration" but the effects of time are even more pervasive.

The following figure highlights the major reasons for non-optimal performance on large programs. The largest impacts derive from a weak project baseline which in the case of large projects starts with inadequate attention to SBOs and an absence of an expanded basis of design which is also reflected in poor execution performance. We see this identified in other listings of common problems faced by large projects[33].

[33] Ten Common Problems on Poor Performing Programs; PM World Today; August 2011

I will suggest that contractual problems and schedule penalties have a more common root cause, namely, falling victim to the planning fallacy.

All is not lost. A robust set of strategies exist to reduce risks in large engineering and construction projects[34] but are often only adequately considered after options have already been narrowed by risk materialization. If we return to the importance of the project selection or program design step described earlier we appreciate that the deeper analysis required drives us to consider alternative scenarios (configurations) and, if done properly, also their attendant risks and strategies to manage them. Ongoing scenario based risk assessment or even periodic re-assessment of the original risk register is currently inadequate in many large projects given the level and changing nature of risks they are exposed to.

Where Does This Leave Us?

Throughout this paper I have touched on a number of the factors unique in form or scope that act upon large scale projects. My lens has been from the perspective of gigaprograms which afford us the opportunity to see some of the "hidden dimensions" that "unfold" as projects scale. I have sought to provide extensive reference to those interested in delving deeper but perhaps the most comprehensive treatment can be

[34] Candidate Strategies to Reduce Risks in Large Engineering & Construction Programs; PM World Journal; September 2012

found in *The GIGA Factor; Program Management in the Engineering & Construction Industry* (CMAA; ISBN 978-1-938014-99-4; 2011). Finally, I have made a case for considering these large scale projects from a program perspective as a way to improve program design and increase focus on the "white space" between the constituent elements.

Let me close by recapping what I think the greatest opportunities are to improve large scale project performance:

- SBOs – carefully select them; ensure they are truly strategic; articulate them; align continuously with stakeholders; communicate them thoroughly; define top level metrics and track

- Build the "Hole" – round pegs fit best in round holes. Preparing the landscape for success is essential and in large programs this must include owner and collaboration readiness in addition to more traditional project readiness. Contractual and decision making frameworks must be integral parts of this round hole.

- Risk – recognize changed and changing nature; identify all program assumptions and track for cognizance of "assumption migration"; incorporate in a scenario based planning basis; revisit risks and potential mitigation strategies continuously. Balance risk efforts with a similar effort around opportunities.

- BOD^X – establish an expanded basis of design to complement owner's project requirements (OPR). As a minimum this will include a construction basis of design that will reduce requests for information (RFIs) from the field and likely reduce overall CAPEX costs and time. In fuller embodiments the basis of design will include operations and maintenance considerations earlier and at a deeper level aiding in improved capital efficiency.

- Time – this may be the most precious resource on a large project as well as the most important risk, cost and schedule "scaling" factor. Value it and focus on opportunities to undertake activities in parallel through a network based delivery approach as opposed to a more traditional serial execution strategy.

- Decision Making – ambiguity and an over emphasis on consensus building can extend time frames and create unwanted management challenges. Delegations

of Authority must be continuously challenged to ensure decisions can be made closest to the issue at hand.

- Complexity – it is real and today's tools are not adequate. Look for opportunities to remove or limit complexity, but only after you have sought to understand where it may exist in the project. A systems perspective is essential

I am sure I could continue to add to this list, but the essential point is that large projects are different. The challenges and opportunities are different. Scaling matters, most importantly, because of the hidden dimensions that it allows to unfold.

About the Author

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Bob Prieto is a senior vice president of Fluor, one of the largest, publicly traded engineering and construction companies in the world. He focuses on the development and delivery of large, complex projects worldwide. Bob consults with owners of large engineering & construction capital construction programs across all market sectors in the development of programmatic delivery strategies encompassing planning, engineering, procurement, construction and financing. He is author of “Strategic Program Management”, “The Giga Factor: Program Management in the Engineering and Construction Industry” and “Application of Life Cycle Analysis in the Capital Assets Industry” published by the Construction Management Association of America (CMAA) and “Topics in Strategic Program Management” as well as over 500 other papers and presentations.

Bob is a member of the ASCE Industry Leaders Council, National Academy of Construction and a Fellow of the Construction Management Association of America. Bob served until 2006 as one of three U.S. presidential appointees 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 and 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), one of the world’s leading engineering companies. Bob Prieto can be contacted at Bob.Prieto@fluor.com.