



## Introduction to Large Complex Projects

### Key Points

- Large complex projects differ in many aspects from more traditional projects.
- Megaprojects differ from more traditional projects in more dimensions than just scale.
- Scaling up in size has the concomitant effect of “unfolding” unseen dimensions.
- Precepts and assumptions differ for megaprojects.
- Large complex projects require fundamental changes in focus.
- Leadership behaviors change in large complex projects.

### Introduction

This Executive Insight is intended to provide an introduction to the area of large complex projects. In this Executive Insight as well as others in this topic area the terms large complex projects, megaprojects, and giga-projects will be used somewhat interchangeably, largely because the insights and perspectives we are sharing will broadly apply across each of them. It is important to highlight up front the differences between the three, described next, at least as used in NAC Executive Insights.

- **Large complex projects** are broadly those with sizes measurably beyond those of more traditionally sized projects, but importantly have an element of complexity not found in more traditional projects. The threshold for a large complex project will vary by market, but generally will not be less than \$500 million. They usually are much larger.
- **Megaprojects** are large complex projects with costs in excess of \$1 billion. Levels of complexity have grown with scale although that linkage is not the only driver of complexity. Many megaprojects are in reality mega-programs, which are comprised of more than one large complex project. Given this, the term mega-program is used when the efforts are likely to encompass multiple large complex projects being undertaken in a coordinated manner to deliver a strategic business outcome.
- **Giga-projects** reflect a larger scale mega-project with dramatically increased complexity and subsequently longer durations. They can be thought of as having values in excess of \$10 billion. Giga-programs will typically encompass a number of megaprojects.

## Aspects of Large Complex Projects

Large complex projects differ in many aspects from more traditional projects. These differences drive different precepts, assumptions, focus, and leadership behaviors. Various differences are outlined in this Executive Insight and developed, together with other related aspects, in subsequent Executive Insights. Some of the aspects of large complex projects that differ from more traditional projects include:

**Project time scale** — Large complex projects frequently have extended timeframes, which often result in project organizations that range from semi-permanent endeavors to life-cycle provision of services.

**Outcomes** — A strong outcomes focus is needed on large complex projects. Strategic business outcomes (SBOs) become more important than requirements. In some instances large complex projects may be faced with emergent SBOs.

**Stakeholder roles** — Large complex projects require the design and outcomes to satisfy the owner as well as a network of enabling and potentially blocking stakeholders. Stakeholder engagement versus stakeholder management is a core activity.

**Boundary conditions** — Large complex projects are not well bounded, as classical project management theory might suggest. Influences acting to create a semi-permeable boundary include the emergence of new outcomes, new stakeholders, and large numbers of ex-project inputs and assumption drivers.

**Flows** — Flows acting on large complex projects include *transformative* flows inside a task and between tasks; *influencing* flows from external stakeholders or a changed project environment; and *induced* flows from interactions of one or more influencing flows. Flows include physical, information, and instructional exchanges, the arrows if you will, between tasks.

**Flows across boundaries** — Influencing flows shape more traditional transformative flows and may arise from flows crossing semi-permeable boundaries, as well as the interaction between two or more transformative flows present within the project context.

**Requirements** — Owner project requirements (OPRs) often prove to be optimistic (the “planning fallacy”) or incomplete and too narrowly defined. Also, new requirements that emerge during execution is characteristic of long duration complex projects.

**Scope** — Scope must go beyond simply the project’s technical requirements. It must explicitly include a broader set of OPRs, including owner strategic outcomes and mandatory/quasi-mandatory requirements from external stakeholders.

**Tasks** — Tasks are increasingly interdependent, coupled by constraints and white space risks. Tasks may become coupled and entangled, and task limits may change and become open-ended.

**Project organization** — Organizations must be adaptive, flexible, self-renewing, resilient, learning, and capable of responding intelligently to change. The rules of connection within the organization must be simple to facilitate flexible responses to complexity.

**Knowledge management:** Knowledge sharing is a central execution principle:

- Everyone has access to all information needed to do their jobs.

- New information is continuously created and shared.

**Execution focus:** Simplification and flexibility become core features of execution. There is an increased emphasis on fabrication, modularization, and standardization of systems, structures, components, and work processes.

## Precepts and Assumptions Differ for Megaprojects

One could easily think the essential difference between megaprojects and more traditional projects is one of scale. A better analogy, and something that we see more clearly in giga-projects, 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 or whose resolutions were incidental at smaller scales. These unseen dimensions:

- Create new regions of white space that if not aggressively managed serve as nesting and breeding grounds for new, more systemic risks, including black swan risks. These white spaces may also act as homes for new, yet to be discovered opportunities, if we only thoroughly examine and understand the potentials that exist.
- Expose a subtle “coupling” across the giga-project 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
- Create 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<sup>1</sup>.
- 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.” 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<sup>2</sup>. In reality, the types of “assumption migration” we are concerned most about are those that demonstrate  $2\sigma$  or greater behaviors or are particularly sensitive to uncertainty growth when confronted with extended time periods.
- Shift the management focus to the various “flows” that comprise the project, not just the tasks. We discover that the myriad of arrows between tasks are not dimensionless.
- Highlight management dimensions that are less significant on smaller scale projects such as those associated with:

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<sup>1</sup> 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.

<sup>2</sup> 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%.

- Increased strategic importance (achievement of SBOs with their outcomes focus) vs. the output focus of delivering more traditional projects and the emergence of a changed governance regime.
- Owner readiness, not just project readiness, given the increased level of owner organizational involvement and oversight that giga-programs 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.

Table 1 contrasts some precepts and assumptions related to large complex projects with those for more traditional projects.

<b>Table 1: Precepts and Assumptions Differ for Large Complex Projects</b>	
<b>Theory of Traditional Projects</b>	<b>Theory of Large Complex Projects</b>
<b>PRECEPTS</b>	<b>PRECEPTS</b>
1. Project is a temporary endeavor.	1. Range from semi-permanent endeavors to life-cycle provision of services.
2. Total transformation can be decomposed into manageable tasks.	2. Influencing flows shape transformative flows and may arise from flows crossing semi-permeable boundaries and interaction between two or more transformative flows present within the project context.
3. Executing each task in optimal manner and sequence optimizes overall project execution.	3. Influencing flows may change the nature of tasks to be undertaken and how various process flows define, interact with, and drive forward the transformation process.
<b>ASSUMPTIONS</b>	<b>ASSUMPTIONS</b>
4. Tasks are independent, except for sequential relationships.	4. Tasks increasingly interdependent, coupled by constraints and white space risks. Influencing vectors arise from process, influencing, and new flows created from interaction of two or more influencing vectors.
5. Tasks are discrete and bounded.	5. Tasks may become coupled and entangled and task limits may change and at times become open ended.
6. Uncertainty of requirements low.	6. Requirements may emerge in project execution; susceptibility to the planning fallacy.
7. Uncertainty of tasks to be performed is low.	7. Tasks may arise as the result of emergent requirements, influencing vectors, and flow-to-flow interactions.
8. Totality of works to be performed can be described by top down decomposition of total transformation effort.	8. Totality of work influenced by semi-permeable project boundaries, emergent requirements, and influencing vectors. Initial decomposition of initial transformation effort may not define ultimate totality of transformation.
9. Requirements exist at outset of project.	9. Strategic business objectives become more important than requirements, and in some instances, projects may be faced with emergent SBOs.
10. Requirements can be decomposed together with the work to be executed.	10. Requirements must address emergent factors and uncertainty over time as large complex projects often have extended project delivery times and significant considerations of life-cycle factors and needs.

## Megaprojects Require an Extended Focus

Large complex projects require fundamental changes in focus. Project management is no longer just a decomposition of tasks in a well bounded environment. It is more and it is not static. The focus one must bring to large complex projects is contrasted with the more classical focus we see in traditional projects in the following Table 2. Organize, direct, coordinate and control are not enough.

Table 2: Megaprojects Require an Extended Focus	
Traditional Project Focus	Megaproject Focus
1. Project readiness	1. Owner readiness
2. Output focus	2. Emergent outcomes (multi-finality)
3. Tasks and transformative flows	3. Flows including emergent influencing induced flows
4. Stakeholder engagement (partners in success)	4. Stakeholder engagement (partners in success)
5. Other:	5. Other:
Organize	Confirm continued validity of assumptions
Direct	Monitor environment for emergence or changes in influencing flows
Coordinate	Influence flows across semi-permeable boundary
Control	Evolve modified project to anticipate/respond to emerging externalities

## Leadership Behaviors Change in Large Complex Projects

As this Executive Insight has shown, large complex projects differ substantially from more traditional projects. It should come as no surprise then that leadership capabilities, focus and, importantly, behaviors would also have to change. These changed leadership behaviors are reflected in Table 3.

Table 3: Changed Leadership Behaviors Required for Megaprojects	
Traditional Leadership Behaviors	New Leadership Behaviors
1. Individual leadership	1. Group leadership
2. Control and order	2. Motivation and movement
3. Scientific management	3. Transformative leadership
4. Outputs focus	4. Shared outcomes focus
5. Assignment and directive	5. Agreement/acceptance of objectives and goals
6. Hierarchical and siloed	6. Flat communication and information structures <sup>3</sup>
7. Acceptance of normative	7. Questioning (assumption, process, outputs)
8. Adversarial or transactional approach	8. Collaboration and information sharing with stakeholders
9. Management of tasks	9. Management of flows
10. Centralized decision making	10. Engaged and decentralized decision making

<sup>3</sup> Built on lean organizational structures with fewer levels between upper management and line workers.

## Summary

Large complex projects expose the fragility of the current approach to more traditional scale projects. Traditional project management theory scales no better than did Newtonian physics for Einstein's study of the universe.

The Executive Insights referenced here and others covering various aspects of large complex projects are intended to provide insight into their special nature, challenges, and opportunities.

## References

1. *Strategic Program Management*; Construction Management Association of America (CMAA); ISBN 978-0-9815612-1-9; July 24, 2008
2. "The GIGA Factor"; *Program Management in the Engineering & Construction Industry*; CMAA; ISBN 978-1-938014-99-4; 2011
3. *The Program Manager's Role; "Managing Gigaprojects"*; ASCE; 2012; ISBN 978-0-7844-1238-1
4. *Theory of Management of Large Complex Projects*; Construction Management Association of America; ISBN 580-0-111776-07-9, 2015
5. *When Mega Goes GIGA*; ISBN 9780359618934; 2019

The following NAC Executive Insights are also recommended for additional reading:

Executive Insight, Giga vs. Traditional Projects

Executive Insight, Strategic Program Management of Giga-Projects

Executive Insight, Improving Large Project Delivery

Executive Insight, Importance of Strategic Business Objectives

Executive Insight, Stakeholder Management in Large Complex Projects

Executive Insight, Flows in Large Complex Projects

Executive Insight, Business Basis of Design

Executive Insight, Know What You Are Trying to Accomplish: The Primacy of the Scope Baseline

Executive Insight, Coupling in Large Complex Projects

Executive Insight, White Space Risks

Executive Insight, Program Based Engineering/Construction Organizations

Executive Insight, Knowledge Management

Executive Insight, Contingent Execution

Executive Insight, Systemic Risks in Large Complex Projects

Executive Insight, Black Swans

Executive Insight, Opportunity Analysis Executive Insight, White Space Opportunities

Executive Insight, Coupling in Large Complex Projects

Executive Insight, Complexity

Executive Insight, Assumption, Risk Driver & Constraint Tracking

Executive Insight, Management of Assumption Infatuation in Large Complex Projects

Executive Insight, Flows in Large Complex Projects

Executive Insight, Importance of Strategic Business Objective

Executive Insight, Mega Project Joint Ventures

Executive Insight, Owner Readiness  
Executive Insight, Capital Efficiency

### **About the Author**

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