Improving Infrastructure Project Success[1]

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A growing world requires improved and expanded infrastructure. Juxtapose that with the need for massive public investment driven by pandemic created economic weakness and the prospects for significant investment in infrastructure is improved, but as history has taught us not necessarily assured.

We have been through other infrastructure stimulus programs focused on so-called shovel ready projects and have been disappointed. But whether we define them as “shovel ready” or otherwise we need infrastructure projects, especially the largest of them, to be successful.

In this paper we will look at common reasons large scale infrastructure projects fail and importantly suggest some strategies and tactics to improve their success rate. The observations are based on the author’s experience in reviewing, troubleshooting and overseeing over one hundred billion dollars plus projects. The extensive end notes are intended to give the reader the opportunity to explore specific items more fully.

Framework for considering large scale infrastructure projects

Over the course of the author’s work, he has drawn certain views as to how we should think about and consider projects such as the large-scale infrastructure projects which are the subject of this paper. Much has been written by others on why large infrastructure projects fail ranging from optimism bias to strategic deception and that is not reviewed here.

The author’s framework is founded on the following core observations:

- Project management theory (classical PM theory) as promulgated by Gantt and Fayol fails at scale and complexity. These are the very characteristics of large complex infrastructure projects.
- A neo-classical PM theory is required that addresses the challenges of scale and complexity such as that exhibited by large complex infrastructure projects. This new theory of project management must:

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- Recognize the open systems nature of these projects and draw on insights from general systems theory
- Recognize the recurring discrete weaknesses in the very foundations of these projects, and address and mitigate these weaknesses
- Address the dynamic flows which are characteristics of large complex infrastructure projects and open systems in general
- Recognize the dominant role of stakeholders and shift from management to engagement

- Metrics both to ensure success as well as to measure what success is are often lacking, not cascaded down through the project and fail to recognize the emergent behaviors related to large infrastructure projects such as migrating strategic objectives and perceptions of benefits realized. These later points arise from the extended time frames often associated with such projects.

Common reasons why large-scale infrastructure projects fail

Large scale infrastructure projects fail for three broad sets of reasons:

- Project foundations[i] are weak
- There is an over focus on tasks while flows are largely ignored
- Stakeholder engagement falls short and the extent of their influence on ultimate project success is underestimated

Key aspects of the **weak foundations** alluded to above include:

- Governance[ii]:
  - Weaknesses in strategic business objectives (SBOs)[iii] and associated key performance indicators (KPIs)
  - Inadequate prioritization[iv] - Prioritizing infrastructure investments is critical in a financially constrained environment. We must maximize capital efficiency by ensuring that we are doing the right things; doing enough of the right things; doing right things right.
- Owner readiness[v]
  - Inadequate owner readiness and processes
  - Inadequate decision frameworks
  - Inadequate valuation of time
- Project readiness

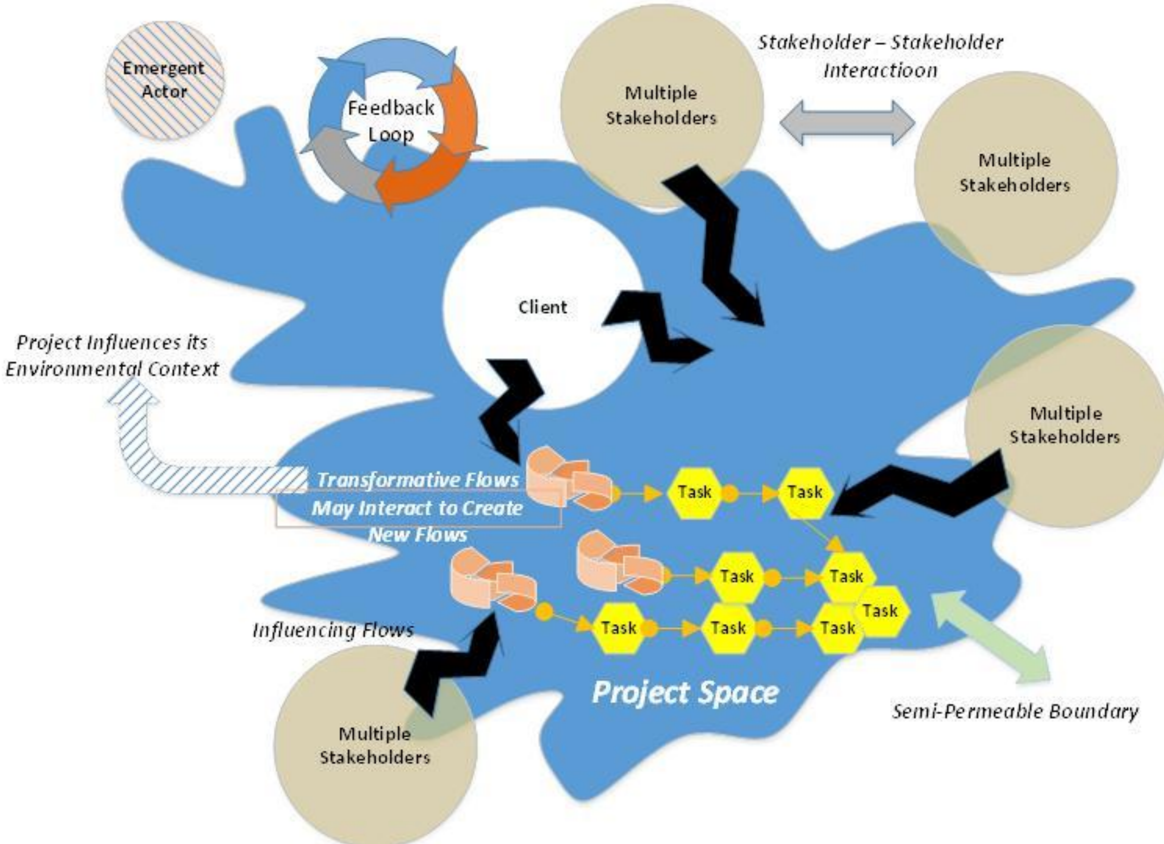
    - Incomplete overall project scope[vi]
    - Incomplete basis of design[vii]
    - Lack of startup granularity
- Planning fallacy[viii]
    - Optimism bias in estimates and lack of clarity about their uncertainty
    - Poorly founded risk assessment and modeling
    - Unconsidered risk classes – Black Swans[ix]; "White Space" risk[x]; Black Elephants
    - Constraint coupling[xi]
- Inadequate project management framework (classical vs. neo-classical)
    - Inadequate understanding of complexity
    - Assumption migration[xii]

Focus on flows[xiii], not just the myriad of project tasks. Those interconnecting arrows in the overall project work breakdown structure (WBS) are not dimensionless. Large complex infrastructure projects are subject to three distinct but related flows:

- Transformational – these are largely the flows envisioned by Gantt and Fayol as occurring within a well bounded project.

- Influencing – these arise from outside the project proper within a broader stakeholder ecosystem than is traditionally considered from a stakeholder management perspective. They cross the semi-permeable boundary of these large infrastructure projects violating one of classical PM theory's foundational assumptions. They interact both with tasks but also with transformational flows.

- Induced – these flows arise from the interaction of influencing flows with each other as well as existing transformational flows giving rise to often short duration but highly destructive flows and eddy like feedback loops.



Large Complex Projects Don't Follow Classical Transformation Models

Stakeholder engagement falls short of large infrastructure project needs. We delude ourselves to believe we can manage these external parties when at best we can engage with them and hopefully influence them. Large infrastructure projects rarely technically fail. Rather there is a failure of stakeholder engagement. These projects require a significant shift in project control efforts from primarily internal ones, underpinned by the notion of a bounded project associated with classical project management theory to a more balanced internal and external focus reflecting the semi-permeable project boundary we actually observe on large infrastructure projects

Much more can be said on why infrastructure projects fail but the reader is encouraged to take advantage of the links in the end notes[xiv] [xv] [xvi] [xvii].

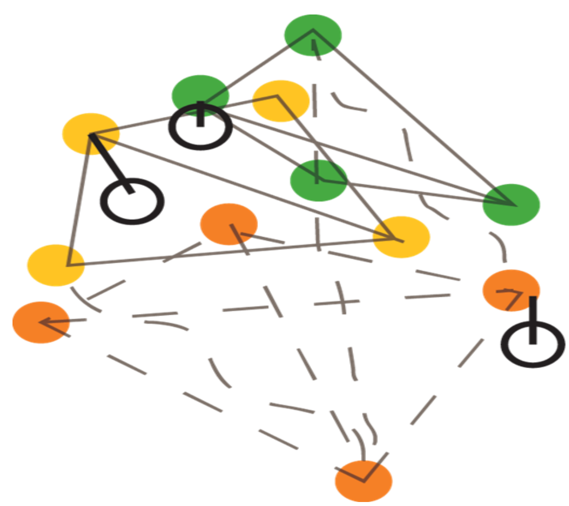
Solutions to improve the success rate of large infrastructure projects

The balance of this paper will seek to identify both strategic as well as tactical solutions to improve the success of large infrastructure projects. The reader is cautioned that there is no silver bullet and some of the strategies, in particular, may be judged as being culturally unacceptable or falling into the too hard category.

The solution sets offered will generally follow the framework laid out at the beginning of this article but given the scope and complexity of the subject the reader will again be guided to the endnotes to delve deeper in any particular area.

Project Management Theory

Large infrastructure projects demonstrate the evolutionary nature of all complex systems. They face uncertainty and emergence that comes with human actions and interactions. They struggle from insufficient situational awareness, treating the project to be more well-bounded than reality would suggest and using simplified models to understand the complexity inherent in execution. Best practices from project management were typically not derived from such environments and, worse, have fallen short on other large complex projects.



Large infrastructure projects are characterized by boundaries that change in response to changing environments; emphasize coping with challenges and change; go beyond uncertainty and require a change in perspective; face a high level of unknown unknowns and unclear/incompatible stakeholder needs.

Improving large infrastructure project success must start with a changed perspective and decoupling from those elements of project management theory and practice which are not delivering the results we require.

Governance

Strategic Business Objectives (SBOs) are the core element in effective project governance. In a dozen and a half projects which the author personally troubleshot it was the one ingredient that was inadequate in all of them. Ensure alignment, continuous alignment, on the overall infrastructure program's strategic business outcomes and individual project objectives. This begins with strong and continuous communication, especially important given the dynamic nature of implementing organizations over the extended time-frames often associated with such programs. Feedback is essential.

Governance processes must recognize the social system imperatives of engagement, transparency and trust which are essential to effectiveness. Trust provides the freedom of action which is necessary when faced with irregular operations or out-right crisis.

Many large infrastructure projects are, in reality, multi-project programs. In these instances prioritization of investments in a comprehensive and transparent way is essential. This prioritization happens with consideration of a broad set of societal, project and other desired outcomes. This multi-factor prioritization helps sharpen the final SBOs that will drive the project.

Among factors[xviii] that must be considered are:

- **Economic** – encompassing societal, agency (or governmental unit), and project considerations
    - Societal related economic considerations can include job creation; infrastructure efficiency; new opportunities created; level of quality of the system; contribution to directional desired change
    - Project level considerations focus more on the capital efficiency[xix] of the developed assets
- **Social** – including stakeholder related concerns and desires; contextual and cultural appropriateness; compatibility with community goals and other social objectives, including social equality and justice. It is important to recognize that stakeholders may include non-local interests such as seen from national level NGO's, trade unions and business interests.

- **Environmental** – including both the environmental impacts associated with project construction and operation but also the effects of longer term environmental factors including global climate change on our infrastructure facilities, systems and structures. Emerging considerations related to embeddedcarbon are receiving more attention. Health, safety and security considerations may be considered in this context as well.
- **Political** – infrastructure is an important political and policy tool and outcome; equity - impact and benefit distribution.
- **Sustaining Capacity and Capability** – ensuring that public and user safety are sustained at acceptable levels and that operational and performance requirements are met throughout the life cycle by maintaining our infrastructure assets in a state of good repair. Emerging considerations around resilience as reflected in achievement of defined recovery timeframes represent new considerations for sustaining the capability and capacity of many infrastructure assets.

Owner Readiness [xx]

Owner readiness is a primary contributor to the success of large infrastructure projects. Owner readiness is separate and distinct from project readiness. Owner readiness with respect to an individual project and associated decision frameworks and processes begins with clearly articulated Strategic Business Objectives (SBOs) supported by a reinforcing strategy. SBO Key Performance Indicators (KPIs) must be established and linked clearly and tightly to the owner's top-level objectives. The notion of cascading objectives is essential to success. Owner organizations that have not clearly thought this through run the risk of competing, or even worse, contradictory objectives.

The owner's strategy for implementation must demonstrate strong linkage to SBOs and be directly focused on their achievement. Strategy must be supported by transparent and substantiated top-level business assumptions. In organizations not sufficiently ready to undertake a major project or a project that is prematurely announced, it is not unusual to see a lack of a shared understanding of the project's context. Specific assumptions and context defining factors that the owner's organization must be cognizant and comfortable with include those with respect to:

- Demand related forecasts
- Factors related to program revenues
- Owner's financial condition
- Resources available to the project
- Competing projects and associated resource requirements and timing

- Assumed changes to law, regulation, or policy impacting owner and project and anticipated timing
- External environment
- Operating strategy and required life-cycle performance
- Owner's risk posture and philosophy

Project objectives and criteria must be reflected in the project's scope and the embedded assumptions transparent and tracked. Articulation and integration of owner's philosophies across a wide range of areas is essential. Large programs must do more than just be aware of the assumptions made in strategy development. They must track them throughout the program life cycle. One of the greatest challenges large, long duration programs face is "assumption migration." The owner's awareness of the assumptions made and the organization's focus on tracking their migration and, importantly, understanding the implications of their trajectories are essential elements of owner readiness.

Planning and execution approach begins with completeness of baseline documents pre-sanction. As part of readiness activities, the owner's organization must have a secure handle on several execution processes that include but are not limited to:

- Business model, scenarios, and relationship to program.
- Prerequisites for owner's executive approvals and linkage to a formal stage gate process, including clarity and comprehensiveness of stage gate requirements and processes; stage gate approvals, authorities granted, resource commitments and constraints; and an approvals matrix.
- Prerequisites for external approvals.
- External approval requirements, timing, and likelihood.
- External prerequisites linked to stage gates including regulatory approvals required, process clarity, and timing, including safety case requirements; and process for property acquisition.

The owner's organization must also demonstrate readiness to:

- Implement the stage gate process, consistent with the owner's own requirements and consistent with a project's demands. Approval time frames, gate expectations, and nature of obtained approvals at each gate must tie clearly into project execution strategies.
- Support management of demand for capital.
- Drive capital efficiency in projects as they advance through the stage gate process. Among various elements of owner readiness to be considered would be the early

focus on construction realities, constraints, and opportunities that may be found in appropriate means and methods selection.
- Enhance project execution by providing a disciplined project development framework.
- Provide effective evaluation of alternatives, including consideration of life-cycle cost and performance evaluations. Significant life-cycle performance benefits can accrue from incorporation of operations & maintenance (O&M) considerations in the earliest stages of a program. Many programs suffer from later stage changes because of lack of an early focus in this regard.
- Influence acceptable risk frameworks commensurate with investments being undertaken and the risks the project will face.
- Provide independent validation and verification.

The owner's organization must be internally aligned. The author has witnessed too many instances of bureaucratic silos within owner organizations frustrating progress and smooth working relationships.

Finally, the owner must be prepared to receive bad news. There are several noteworthy examples of where senior staff has blocked the transmission of bad news, changing reporting formats and definitions or blocking CEO level conversations. Owners of large infrastructure projects should routinely meet with C-suite individuals from their major contractors.

Project Readiness

Project readiness must begin by addressing the human element, building a team and a shared culture from the outset. Team buy-in is essential for large infrastructure project success. Top-down planning creates a perception of "expediting" and limited team buy-in delays "front line" decisions, acceptance of responsibility and constructive suggestions and feedback that are hallmarks of successful projects. Early engagement of the team is useful in identifying any missing skills in the team or other undesirable team behaviors.

Creating a team culture requires us to recognize that team building is never complete and that feedback mechanisms to assess "team" performance must be in place from the outset of the project.

Project baselines must be complete and in place. Among the baselines, scope has primacy. The scope of work consists of two principle elements, a scope of facilities and a scope of services. Incomplete or inadequate scope definition and management has been identified as a major source of degraded project performance. The International Association for Contract & Commercial Management (IACCM) has identified 10 common pitfalls for contract management. Number one among these is a "lack of clarity on scope and goals." Others have identified that when scope is not clearly and accurately defined, overruns become systemic; scope creep is a consequence and the second highest rework indicator.

In addition to cost overruns arising from poor scope definition, delayed completion and disputes often occur as well. If scope is prescriptive, then identify all elements and services, document all elements required for a "complete" project that are not within the prescriptive scope, and confirm that they are to be provided by the owner or through another contract. Document critical interfaces and include them in the contract or in an early contract deliverable that requires the owner's acceptance. Opportunities to utilize outcomes-based contracting[xxi] for well bounded segments of the project should be considered.

Evolving artificial intelligence tools promise to aid in scope "testing" for completeness. Development of the SOW is aided by development of a project work breakdown structure (WBS) and the two activities typically go hand in hand.

A recurring shortcoming in large infrastructure projects is lack of readiness for project startup[xxii]. This is commonly seen with respect to utility relocations where the required engineering packages have not been prepared in the sequence required for construction and prioritization has not been communicated to the requisite utility companies. On one large infrastructure project a 50,000 element WBS included just five, one for each utility, for utility relocation package development. There were 600 distinct packages required linked to various construction work packages!

Owner's project requirements (OPR) must be well developed and aligned with SBO's and strategy. Below we will discuss why these are often incomplete and what needs to happen to address this.

Planning Fallacy

One feature seen repeatedly in public sector projects is overassessment of the quality of the estimate. Uncertainty associated with an estimate must be explicitly stated. Expected values do not account for unknown risks not explicitly considered as the estimate was developed.

Large public works infrastructure programs have two cost exposures not traditionally encountered in best of class projects. The first deals with the planning fallacy. In general, the stage gate processes in a non-political/not-public environment squeeze out many (but not all) opportunities for an optimistic bias. This is not always the case in public projects. Some have suggested that this planning fallacy may be linked to "strategic deception"[xxiii].

The second deals with the cost of delay[xxiv]. Large scale industrial projects often involve the sanction of large up-front equipment and material purchases. As such, when the trigger is pulled it is really an all-out sprint. This doesn't mean events don't stop a project but in general the cost of general delay is not a significant cost risk.

Public works projects and approval processes add a cost of time to a project that is not typically reflected in the agency's estimate. Benevolent escalation has lulled many to sleep but this does not last.

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 class forecasting. This estimate benchmarking process is widely used in the process industries and should be considered for all large infrastructure projects.

Keys to controlling this planning bias are:

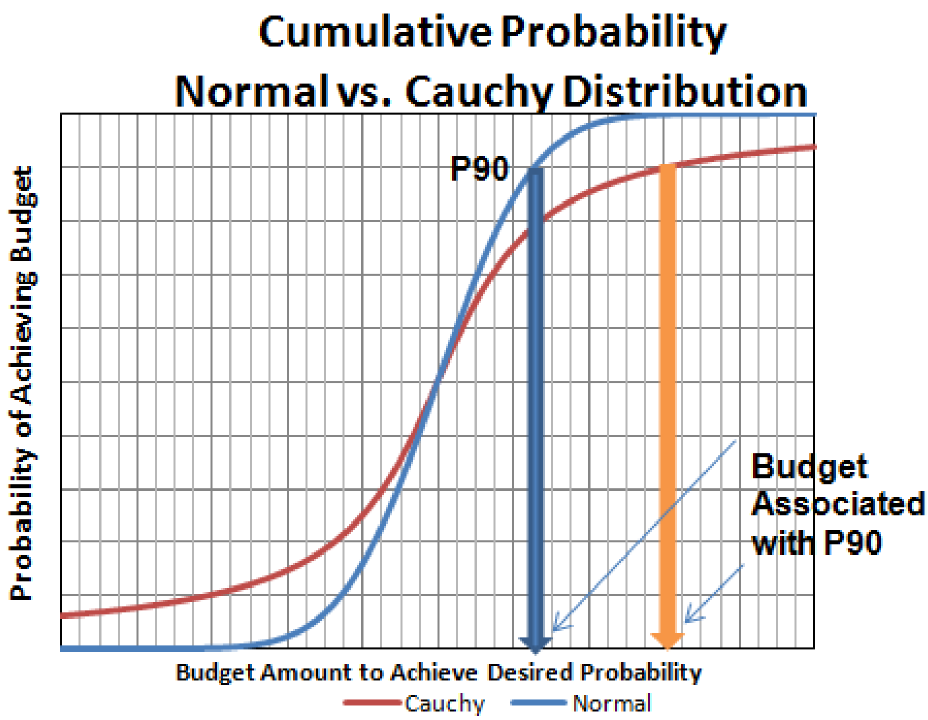
- **Assumption articulation and tracking**–assumptions must be explicit, tested, confirmed and importantly monitored. In highly complex and long-term projects assumption migration is a regular occurrence.
- **Consideration of all risks**, no matter how improbable, that could adversely impact the project or program plan[xxv]. "Framing questions" and an optimism bias often lead us to assume away risks leading to a failure of not only developing management strategies and contingencies, but even worse, failing to track them further.
- **Directly addressing the bias** through use of reference class forecasting that provides separate empirical-based evaluation. Reference class forecasting provides a neutral ruler against which to measure our planning efforts.

Another dimension of the planning fallacy is how risk is assessed and modeled. While risk management has come a long way there remains significant room for improvement.

Quantitative risks are not comprehensively assessed and often there is an over reliance on "factors" from prior projects without understanding differences between projects. Importantly, event risks are not adequately addressed and "known unknowns" are often not factored into risk analysis. We see this routinely with so called "Black Elephants"[xxvi] [xxvii]

Specifically, large infrastructure project risk assessment and modeling must:

- Address the presence of "Black Elephants" both external to the project but also within the project organization, structure and decision frameworks. (See Table 1)
- Include consideration of perceived low probability high consequence events
- Recognize that in complexity projects perform more catastrophically consistent with their open systems nature. Fat tail[xxviii] distributions must be considered and capabilities and capacities for any required response identified and put in place.



- Recognize that there is a significant element of coupling and risk correlation within large infrastructure projects which contributes to a potentially significant increase in overall risk consequences[xxix]
- Select appropriate confidence levels recognizing the potential for optimism bias, inherent complexity and uncertainty. Consideration must also be given to the confidence levels that contractors will using in preparation of their bids. Taken together estimates should be based on measurably higher confidence levels than P50.

Complexity and uncertainty are discussed further in the next section.

Table 1 - Black Elephants in Projects	
Project Foundations	Strategic Business Objectives (SBO) absent[2]
	Strategic deception/ unrealistic baselines/ optimism bias
	Incomplete project selection[3] and definition[4]
	Inadequate risk assessment and management process[5]
Owner Organization	Lack of transparency
	Owner organization not ready/ not capable to undertake project[6]
	Resistance to bad news
	Unwillingness to allow CEO level conversations
	Failure to make timely decisions
Project Team Behaviors	Weak ethical culture
	Weak safety culture
	Lack of alignment of project team and owner

[2] Executive Insight, Importance of Strategic Business Objectives; https://www.naocon.org/wp-content/uploads/The-Importance-of-Strategic-Business-Objectives.pdf
[3] Executive Insight, Infrastructure Investment Prioritization
[4] Executive Insight, Know What You Are Trying to Accomplish: The Primacy of the Scope Baseline; https://www.naocon.org/wp-content/uploads/Know-What-You-Are-Trying-to-Accomplish-The-Primacy-of-the-Scope-Baseline.pdf
[5] Executive Insight, Owner's Risk Checklist
[6] Executive Insight, Owner Readiness; https://www.naocon.org/wp-content/uploads/Owner-Readiness.pdf

Table 1 - Black Elephants in Projects	
	Mismatch between team capabilities and project complexity
	Too many precedences and couplings in schedule
Management Inadequacy	(Just) managing versus leading
	Administering versus managing
	Irregular management reviews of project
	Root causes of productivity challenges left unaddressed
Common Externalities	Significant unresolved stakeholder issues (internal; external, including political)[7]
	Unaddressed labor strife
	Significant supply chain and logistical challenges

Inadequate project management framework[xxx]

There are several elements of the project management framework which present opportunities for improving success rates of large infrastructure projects. These may be grouped into:

- Basis of design
- Planning
- Organization and decision making
- Project control

Basis of Design[xxxi]

Large infrastructure projects are challenged in three significant ways:

[7] Executive Insights, Stakeholder Management in Large Complex Projects

- **Capital efficiency of the project**: this considers both first costs as well as life-cycle costs.[xxxii] [xxxiii] [xxxiv]
- **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, which is often an essential ingredient in capital efficiency.

Capital efficiency in large infrastructure projects is improved through the adoption of an expanded basis of design that considers all aspects of a capital asset's life cycle. In many projects today, the basis of design (BOD) largely encompasses the engineering parameters required to meet the owner's project requirements (OPR). Constructability (defined by CII as "construction input to design") 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.

Much more is required to develop effective designs that reflect 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 change suggested here is about a shift in mindset and perspective as well as in our design work processes.

An expanded basis of design (BOD^X) encompasses the traditional engineering basis of design as well as encompassing construction and O&M considerations. Bringing these consideration right up front:

- Drives innovation
- Improves constructability, identifying any unique challenges much earlier and shapes the design and design process to improve the construction process and associated productivity
- Reduces requests for information (RFI)
- Reduces the potential for design changes by later stage requests from O&M

Planning

- Recognize that project plans, no matter how well developed, will likely not survive real world contact. Work sequencing and established organizational and communication hierarchies will break down to different degrees. The resultant requirements of contingent execution and broad 360°communication represent organizational properties which must be inoculated into project planning.

- Incentives work and careful pre-thought about the best type of incentives to be deployed (given the project setting), the level of such incentives, the clarity of outcomes to be achieved to earn such incentives and importantly, the timing of their use. This last point is important. All too often incentives are deployed when the program has already come off the rails whereas they may be more effective in keeping the program on the rails. One excellent example is in mature safety programs where safety bonuses are earned as the projects advance and lost until sustained safe performance returns for a defined period.

Organization and decision making

- Prepare the organization and execution strategies and plans for four types of operations:
    - Regular
    - Irregular (often the norm)
    - Emergency
    - Catastrophic/contingent – this mode of operations focuses on true resilience of the program execution operation and plan. It most certainly aids in handling Black Swans but also the Black Elephants[xxxv] we often ignore. This concept of operations is characterized by flexibility, adaptability, responsiveness, capabilities and capacities.
- Define team to include not only the resources immediately available and under the program's day to day control but also the broader set of skills, knowledge and authorities that will act to enable execution. Importantly, stakeholders need to be viewed as team members and not adversaries and appropriately engaged in successful program delivery. This last concept is often the very antithesis of traditional project management's closed system thinking.
- Empower the execution team by defining outcomes, expectations, behaviors, values, responsibilities and engagement with the broader team. Emphasize 360°communication and prudent risk taking. Emphasize use of self-directed teams focused on contributing to achievement of overall outcomes (SBOs). This is the antithesis of Taylor's assembly line where each team member is only focused on a narrow accomplishment.
- Penalty for "taking personal risks" must not outweigh the penalty for "failing to take personal risk" (retribution vs. reward culture)

- Ensure team composition matches the range of potential changes and challenges in the external environment. Adequate team diversity of skills, experiences and thoughts is essential. When problems are complex, diversity (cognitive differences) trumps ability. Access to required diversity can be accomplished by access to others outside the project team.[8]
- Recognize that sole-decision making may be required under chaos but even then decisions benefit from a diversity of views and challenge.
- Strong process, procedures and performance are supported by strong social capital. Connections between people (team members; stakeholders) must be built early and continuously sustained and nurtured. Alignment, collaboration and true leadership act to increase social capital. Effective use of social networks to gather knowledge and support are leading indicators of project success.

Project control

- Risk and opportunity must be equally managed. Recognize that entropy (disorder and randomness) are present and create or contribute to threats and opportunities depending on how we address them.
- Ensure comprehensive understanding of changes, including disruptions, on the entirety of the project. They are not discrete or localized events; they change the project in ways we must seek to understand. Emergent properties are visible only when considering the project as a whole.
- Related to this is ensuring root causes are understood and not acting elsewhere in the project or subject to recurrence at a later stage.
- Understand that traditional project control systems actually control nothing but rather act to inform[9] and influence the real control points, the individuals on the team and to a lesser degree various stakeholders. This does not alleviate the need to strengthen project foundations[xxxvi]. Also recognize the broader environment often acts to constrain or otherwise dictate the actions which individuals can or choose to take. Leadership is important.
- Meaningfully deploy strategies for leverage shown in Table 2 to guide the project to its desired outcomes.

[8] Law of requisite variety from cybernetics
[9] Estimating uncertainty and measuring variance

Table 2 - Strategies for Leverage[10]
Preserve flexibility of response (contingent execution)
Provide for decentralization of decision making and action (Workface Planning)
Encourage 360°communication
Resist opening of regulatory and control loops without dealing with full effects on the program (Law of unintended consequences)
Identify critical points of weakness or control and act upon to reinforce or retard change
Decentralize program and project control to retain overall control on large complex programs
Resist changes unless full program impacts understood
Do not remove or impose constraints without understanding why they existed initially or the systemic impact of imposing them
Encourage diversity of thought (Avoid cognitive lock)
Encourage prudent risk taking and require people to "tell, tell, tell"[11]
Set outcomes. They allow for feedback.
Transparent broad distribution of information leads to good outcomes. Knowledge is most powerful if everyone has it.
Value time and timing

- Recognize and address complexity. Uncertainty in large infrastructure projects creates ever changing (dynamic) latent risks. They require ambiguity to be continuously eliminated and there must be recognition that they often perform in a degraded mode. Large infrastructure projects require more and transparent information to control project entropy and capabilities and capacity for contingent execution are essential.
- Control the "white spaces" through enhanced assumption tracking, coupling identification and reduction of precedences and couplings in project networks. In two cases for urban rail systems, a change in contract packaging strategies resulted

[10] Adopted from De Rosnay "The Ten Commandments" of the Systemic Approach"
[11] Admonishment to young staff earlier in my career: "If you don't screw up at least once a day you are not doing your job!" Corollary was "tell, tell, tell". Then we can help you fix it and learn from it.

in schedule reductions of 15 and 20%. Seeking out "white space" opportunities[xxxvii] is also essential to control of the project.

- Apply information about potential project outcomes to proactively manage and control the project. This is an area where advances in AI[xxxviii] [xxxix] are particularly promising.
- Manage the prime contracts[xl]. Contract disputes[xli] are a regular and costly activity on large infrastructure projects. Typical disputes, such as differing site conditions and the impact of owner changes, involve a variety of factual issues. It is not unusual for the most contentious arguments, however, to focus on whether the contractor met the administrative requirements of the contract for its claim, such as filing a timely notice of the claim. In reality, many contractors fail to comply with these administrative requirements. This may occur because the contractor's project team does not fully understand what is contractually required for a given situation. Often it is because the contractor has a reluctance to confront the client or a belief that the team can resolve these items later as a group. Monthly review meetings[xlii] with the client should have identification and resolution of these issues as a standing item.
- Kickoff each project phase or major activity with a review of prior lessons learned.
- Ensure meaningful, regular project reviews are happening with well-established agenda, data to drive decisions and the right people at the right level participating.
- Real time project status is essential.

Focus on Flows

Large infrastructure projects don't follow classical transformation models. It is essential for the project team to focus on flows[xliii], better managing their timing and coordination; understanding their impact on other flows; and, importantly, anticipating their changes and rates of change[xliv].

Strategies that aid in achieving successful outcomes include:

- Standardization of systems, structures and components
- Standardization of work processes
- Decoupling of activities that can be undertaken independently
- Precedences and unnecessary coupling or correlation of activities must be reduced
- Work plans must facilitate contingent execution[xlv]. Recognize that even in the most robust plans variability may require related tasks to be either accelerated or delayed to reflect project realities. This variability is made more acute as influencing flows enter and interact with the project plans and activities. Management of this

> variability requires an ability to execute project activities on a contingent basis, responding to or taking advantage of temporal variability in the execution and completion of the myriad of project activities and tasks. In effect, to the extent possible, project plans must have a degree of temporal flexibility.

Lean project management begins the integration of traditional methods and human characteristics with system flows replacing pure input/output measures. While providing the flexibility to move beyond static constructs and respond to dynamic behaviors, it potentially introduces new risks. Large infrastructure projects require capacity and capabilities to support the inevitable need for contingent execution in the wake of influencing flows.

Influencing flows and those that they induce arise external to the project and may represent some of the greatest challenges to success that large infrastructure projects face.

Special attention should be paid to the sources and frequency of out of sequence work arising from subcontractors working in multiple locations at the same time; incomplete work areas; overlapping crews/subcontractors; and overlapping work areas.

Formal continuous process improvement in all activities and processes is essential.

Stakeholder Engagement

Large complex projects demand a different type of relationship and management approach to the broader and ever-changing stakeholder environment which is acted upon by the project and which in turn acts upon the project. The disruptive effect of stakeholder driven change can be significant.

The stakeholder environment of which the project is a part can be characterized as including the project itself as an equal actor in this complex ecosystem. This is a key point as the project de facto commands no higher position than any other potential stakeholder. The illusion of preeminence or priority has degraded stakeholder relationships on many large infrastructure projects with corresponding poorer outcomes.

New measures are required to anticipate stakeholder perceptions of project actions and impacts. These new measures represent a key portion of an expanded set of control points focused externally to the project. Stakeholders throughout the full project life cycle must be considered since success or failure is often judged well after initial construction has been completed. Work on project success factor scales have shown the strongest correlations to be with public stakeholder satisfaction; contractor satisfaction; and supplier profitability.

Infrastructure project success requires us to:

- Continuously engage stakeholders in reaching consensus on the newly emergent stakeholder issues that are inevitable given the fluid boundaries associated with large infrastructure programs.
- Seek broader input into what is often dynamic problem solving. This expertise may be crowd sourced in manners similar to those employed in open innovation. The crowd may include stakeholders recognizing that owner led 'engagement' often shifts to a perceived 'management' of stakeholders as the execution team is established and begins operations. During execution, engagement grows in importance and the notion of stakeholder management should be discarded to the dustbin of failed best practices.
- Recognize that stakeholders do not exist in isolation and that they are part of a broader interacting ecosystem. Even when the number (N) of potential stakeholders may be limited there are still $(N^2 – N)/2$ potential communication channels between them that may act as sources/precursors to influencing flows.

A new stakeholder engagement strategy should be considered which the author has referred to as sentry, scout, and ambassador[xlvi].

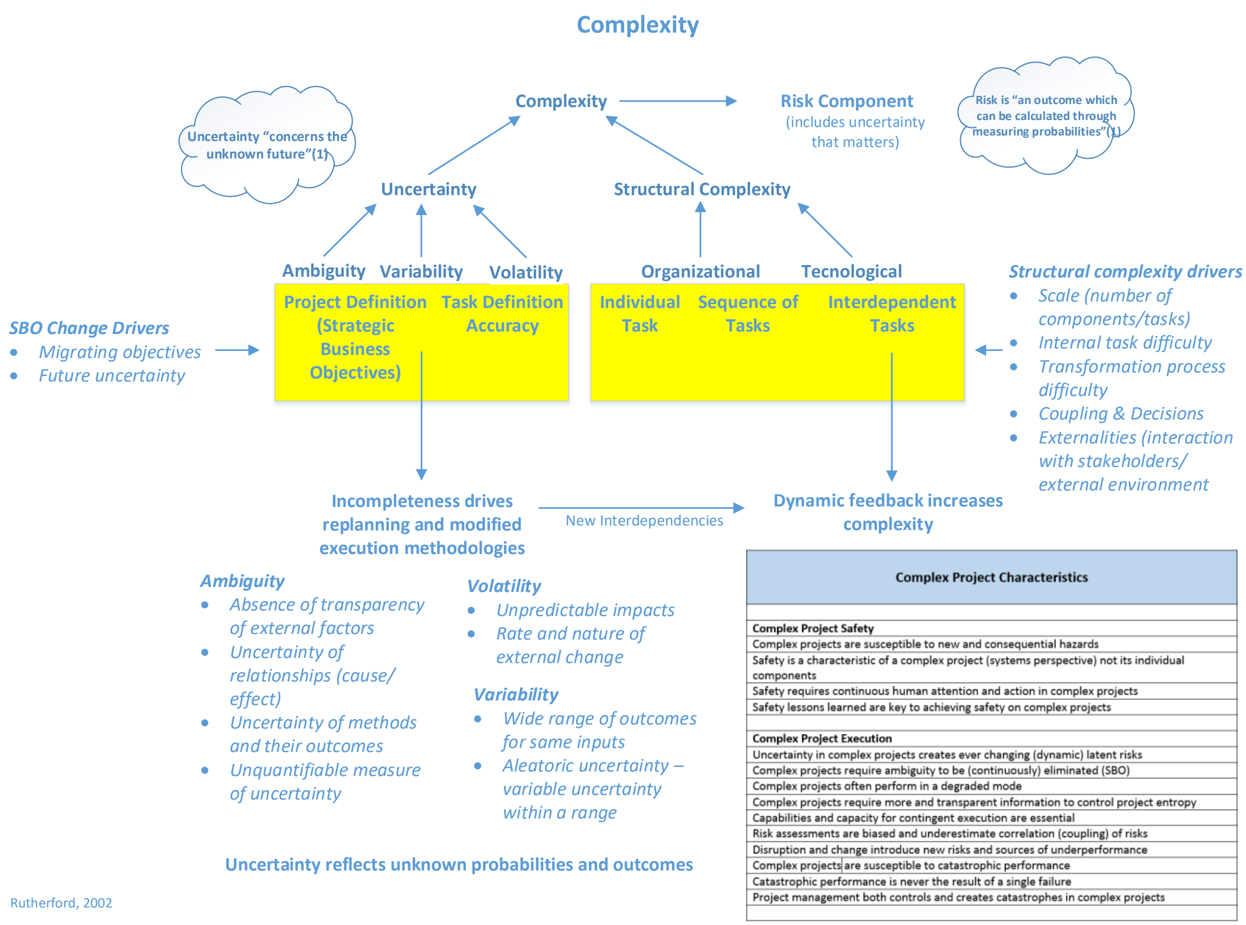
Metrics

Large infrastructure project metrics fall short in several different ways all of which are addressable:

- Key performance indicators (KPIs) do not cascade down from top level SBOs. A review of the linkage of project metrics as they roll up often highlights the introduction of "wants" versus "needs" into the project scope. KPIs must clearly be linked to SBOs and cascade through the project.
- Key performance indicators are largely a recording of what has happened versus what may happen next. They are not predictive and thus of limited value in driving the project forward. Predictive AI can improve project foresight. It is important to understand the training data behind AI algorithms and confirm it is fit for purpose.
- Metrics must be carefully chosen, recognizing their ability to drive behaviors[xlvii] and inadvertently drive unintended consequences. For example, activity measures may result in a lack of results and create additional work for staff, while result measures may involve a limited understanding of the results, generate questions as to why they are not being achieved, and create large amounts of duplicate or uncoordinated activity. A balance is required.

- Baseline metrics (cost, schedule, risk, cash flow) must be expanded to track migration of underlying assumptions; factors driving consumption of contingencies (to determine if they persist and will impact the project more broadly); changes in risk profile either driven by new risks emerging, assumption migration or retirement of risks; and dynamic supply chain forecasting using available AI "control towers"[xlviii] adaptable to the infrastructure space.
- Safety metrics, especially near misses, provide insight into how well planned and supervised project execution is.
- Cost related metrics must effectively measure and manage indirect costs including project administration and indirect field costs[xlix]. Implement cost containment programs from the outset of the project.
- Contingencies should include provisions for uncertainties caused by third parties, regulatory changes, right of way acquisition and utility relocations. Identify incentives that will drive project success.
- Schedule performance metrics need to strongly deploy the concept of earned schedule (SPI_t)[l] instead of the more common SPI. Quantify the value of time.
- Foresight based forecasts, likely AI enabled, must become the new normal for large infrastructure projects.
- Quality metrics must treat quality as performance excellence as viewed by all stakeholders. quality has three essential attributes:
    - **Relationship quality** – Measure achievement and satisfaction with obligations, stated or implied, to our customers, our employees, our suppliers and subcontractors, our partners and all other stakeholders we engage with and have obligations with respect to.
    - **Fit for purpose** – Efficiency of construction related to both productivity and schedule. Effective use of BIM, standardization, pre-assembly and modularization must be tracked against established goals. Life cycle efficiency including overall capital efficiency[li] must be measured.
    - **Right the first time** – Number of RFIs and cumulative effort spent preparing and responding; rework required as a result of RFIs; and claims arising as a result of an RFI. Rework levels and reasons are tracked and reviewed against budget and contingency levels (measures effective project management coordination; goal is zero percent rework). Early RFI trends provide insight into design management challenges.
        - Everyone is actively engaged in identifying errors before they reach customers (Underscore "Do it right the first time.").
        - Best practices are systematically identified, shared, and improved upon (a learning and continuous improvement culture is strengthened)

- Track bid package completeness. Incomplete bid packages impact cost and schedule. Do it right and complete the first time.
- Stakeholder metrics
  - These are among the toughest metrics. Various scoring systems can be developed assessing number of engagement activities by stakeholder group, by engagement type, and by topic; regularity of engagement; recurrence of issues by source and forum; engagement frequency by stakeholder and stakeholder group; trending and root issue analysis.
- Complexity metrics
  - Complexity metrics represent an area of challenge but there are some good analogs available and the focus needs to be on relative complexity versus absolute complexity.
  - Programming complexity[lii] metrics offer particular promise as well as those focused more directly on construction[liii] [liv]



Conclusion

Large infrastructure project failure is well documented and a growing concern. The sources of failure are many and in this paper we focus on how to minimize and possibly eliminate many of these points and practices of failure. The sheer scope of this challenge has necessitated the extensive use of end notes to guide the reader to a deeper understanding on many of the points and suggestions made.

Large infrastructure projects need not fail as demonstrated by those that were successful often because of their use of many of the suggestions for success laid out in this paper. But all human endeavors by their very nature are prone to uncertainty, bias and the natures of human dynamics. This leads us to focus more, much more, on the human aspects of large infrastructure projects including clarity of objectives; team composition and behaviors; and importantly, a changed relationship with stakeholders.

About the Author

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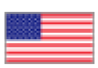

Bob Prieto is a senior executive effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering and construction industries. Currently Bob heads his own management consulting practice, Strategic Program Management LLC. He previously served as a senior 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

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