NAC Executive Insights

Large Complex Programs as Open Systems

Key Points

- Large complex programs are characterized by boundaries that change in response to changing environments.
- Best practices from project management have failed to serve large complex programs well.
- Systems theory represents a different way of thinking about the open systems nature of large complex programs.
- Traditional and neo-classical project management (PM) theories are compared from a systems perspective.
- Specific guidance is provided for large complex programs to be successful.
- Key leverage points in large complex programs are outlined.
- Strategies for leverage are also outlined.

Introduction

This Executive Insight looks at large complex programs from a systems perspective, recognizing that such programs are not as well-bounded as classical project management (PM) theory (as espoused by Taylor, Gantt, and Fayol[1]) would have us believe. Rather large complex programs behave in both independent and interconnected ways in a dynamic systems environment. The focus in this Executive Insight is on open systems, which are analogous to large complex programs.

This Executive Insight highlights the open systems nature of large complex programs, contrasts it with traditional PM theory and, importantly, provides meaningful guidance on mindsets, behaviors, and practices that are required to improve achieving successful outcomes.

Characteristics of Large Complex Programs

Large complex programs are characterized in several ways. They have boundaries that change in response to changing environments. They emphasize coping with challenges. Changes on such programs often go beyond simple uncertainty, requiring a change in perspective. Participants involved in large

[1] See R. Prieto, "Theory of Management of Large Complex Projects"

complex programs will face a high level of unknown unknowns and unclear/incompatible stakeholder needs.

Large complex programs demonstrate the evolutionary nature of all complex systems. They face the uncertainty and the emergence that come with almost every human, government, corporate, and market action and interaction. Large complex programs also struggle from insufficient situational awareness, being treated as if they were well-bounded more than they really are.

These programs also struggle with the overuse of simplified models, which are thought to be useful in understanding the complexity inherent in their execution. Such is not the case. In fact, the best practices developed from traditional project management (PM) theory have shown to fall short when put into use on large complex programs.

Large complex programs inhabit the open systems world. The adoption of a systems approach to the management of large complex programs carries with it a requirement to think strategically.

Systems Perspective

Systems theory represents a different way of seeing, thinking, and acting.[2]

Systems are viewed as greater than the sum of their parts. In systems theory, a system is defined as a configuration of parts connected and joined by a web of relationships. A system's holistic properties can never be completely known. Different perspectives will provide different views that may overlap and not be completely compatible.

Complexity of systems may exist at multiple levels—component, sub-system, system, and system of systems. Flexibility, adaptability, and responsiveness provide resilience in complex systems. Redundancy of information flows and critical resources are essential characteristics in well-performing systems. Time must be managed, first to accommodate disruptions and disturbances, and second, to allow the system to recover.

Systems methodologies are characterized as either hard or soft. Hard systems methodologies, sometimes referred to as "operations research," do not deal as effectively with complex human conflict as do soft systems methodologies. The latter consider the broader environment, including human and sociological elements. Soft systems methodologies also are often iterative, providing learning at each stage.

Traditional vs Neo-Classical PM Theory from a Systems Perspective

Table 1 compares traditional and neo-classical theory of project management (PM) from a systems perspective.

[2] De Rosnay, *Macroscope: A New World Scientific System*, 1975

Table 1 Comparison of Traditional and Neo-Classical PM Theory from a Systems Perspective		
	Traditional PM Theory	**Neo-Classical PM Theory (Systems Theory)**
Predominant Project Type	Traditional	Large complex programs and projects
Foundational Thoughts	Taylor; Fayol; Gantt	von Bertalanffy
Nature of Projects	"Newtonian"[3]; mechanistic; deterministic (Descartes)	Relativistic (Einstein, quantum physics); organismic (Darwin, evolutionary theory); they represent change, not just *are* changed
Nature of PM	Control	Synthesis
Thinking	Reductionist	Anti-reductionist, holistic
Project Boundary	Well-bounded; closed systems do not interact with their environment	Open exchange with environment; open systems have an ongoing relationship with their environment; part of a larger System of Systems (SoS)
View of project	Well-bounded	Embedded in and interacting with other systems (SoS)
Feedback loops	Defined to support positive control (negative feedback loop)	Emergent; positive and negative feedback; reactions to changes in environment (also change environment)
Properties	Defined; fixed; derived from the sum of the parts (components)	Emergent; systemic[4]
Organizations (individuals, groups, departments)	Machine-like closed systems; mechanistic structures (highly specialized, compartmentalized, strict rules, well-defined and rigid hierarchy; well-defined formal tasks)	Flexible organismic structures (decentralized, self-organizing, ongoing process of order-disorder interaction), distributed leadership, extensive interdependence, high individual discretion, informal tasks, 360°communication)
Planning basis	Environment is knowable, predictable; limited impact on strategy and execution	Continuous stakeholder engagement
Stability	More stable closed system; in equilibrium with no exchange with their environment	Less stable open system; potential disequilibrium (bad = disruption; good = change,

[3] Newtonian view held that the universe was made up of closed systems.

[4] Metaphysics (Aristotle) recognized that…"many things have a plurality of parts and are not merely a complete aggregate, but instead some kind of whole beyond its parts…"

Table 1 Comparison of Traditional and Neo-Classical PM Theory from a Systems Perspective		
	Traditional PM Theory	**Neo-Classical PM Theory (Systems Theory)**
		creativity, innovation); stabilized by flows Structural stability relative as it is transferred by exchanges with environment
Emergence	Non-emergent	Emergence of novelty
Strategic Business Objectives; goals	Fixed	Exist in continuous interaction with environment
Complexity	Reductionist approaches do not handle well; complexities considered in isolation from their environment	Complexities considered in context of broader ecosystem; arises from inclusion of relationships as a dynamic property at various levels, starting with components and activities
Most valuable contributor	Specialist	Generalist
Project execution	Master schedule; recovery to the plan	Equifinality[5] recognized; provision for contingent execution
Predictability	Predictable (order); outcome determined by initial conditions	Unpredictable (shifting balance of order and disorder); outcomes influenced through interaction with environment; continual evolution
Logic	Binary; evaluation separates behavior (inside) from environment/context (outside)	Spectrum of possibilities; relational context matters
Nature of Flows	Steady, laminar; clear information	Turbulent; information amidst the noise

Success Drivers for Large Complex Programs

To be successful, large complex programs must include the following key elements.

- Ensure continuous alignment on the program's strategic business outcomes and individual project objectives. This begins with strong and continuous communication, which is especially important given the dynamic nature of implementing organizations over the extended timeframes often associated with such programs. Feedback is essential.

[5] Equifinality is a way systems can reach the same goal through different paths

- If parties do not understand how project goals are being impacted by changes in the dynamic environment, then surprises occur (and often occur late), when they become problematic and then require backtracking. If impacts are not fully understood, then risks should be discussed regarding how things may impact project goals. This will keep the larger team informed and eliminate surprises later. In addition, the risk discussion could lead the team to discover early on some issues that are involved in their interrelated plans.
- Continuously engage stakeholders in reaching consensus on newly emergent stakeholder issues that are inevitable, given the fluid boundaries associated with large complex programs.
- Seek broader input into what is often dynamic problem solving. This expertise may be crowd-sourced in a manner similar to that 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.
- 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 that must be inoculated into project planning.
- Recognize that incentives work. Careful planning is needed, however, regarding the best type of incentives to be deployed (given the project setting) and the level of such incentives. Also, the outcomes to be achieved to earn such incentives should be clearly understood. The timing of their use is critical. To emphasize this last point: all too often incentives are deployed when the program is indicating that failure is imminent, whereas if used differently, they may be more effective in keeping the program on the path to success. One excellent example is in mature safety programs where safety bonuses are earned as the projects advance and are lost until sustained safe performance returns for a defined period.
- Focus on flows[6], with the goal to better manage their timing and coordination. Understand their impact on other flows, and, importantly, anticipate their changes and rates of change[7].
- Prepare the organization and execution strategies and plans for four types of operations:
    1. Regular
    2. Irregular (often the norm)
    3. Emergency
    4. 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 (big surprises that were not foreseen), but also the Black Elephants[8] (big problems everyone sees but no one wants to deal with) that we often ignore. This concept of operations is characterized by flexibility, adaptability, responsiveness, capabilities, and capacities.

[6] See R. Prieto, "Theory of Management of Large Complex Projects"

[7] R. Prieto, "Generalized Analysis of Value Behavior over Time as a Project Performance Predictor," *PM World Journal*, Vol. I, Issue III – October 2012

[8] R. Prieto, "On the Subject of Black Elephants," *PM World Journal* Vol. IX, Issue VII – July 2020

- 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. They should be 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. Also stress use of self-directed teams that are focused on contributing to achievement of overall outcomes (strategic business objectives or SBOs). This is the antithesis of Taylor’s assembly line, where each team member is only focused on a narrow accomplishment.
- 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) outweighs ability. Access to required diversity can be accomplished by access to others outside the project team.[9]
- Recognize that sole decision-making may be required under chaos, but even then, decisions benefit from a diversity of views and challenges.
- Strong process, procedures, and performance are supported by strong social capital. Connections between people (team members, stakeholders) must be built early, sustained, and continuously 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.
- Risk and opportunity must be equally managed. Recognize that entropy (disorder and randomness) is present and creates or contributes to threats and opportunities depending on how we address them. There is a need to understand project risks by all in an open systems environment including when and if they will transfer at some point to one of the parties. This knowledge and understanding is an important context for many when making decisions.
- Ensure comprehensive understanding of changes, including disruptions, on the entirety of the program. Changes and disruptions are not discrete or localized events. They change the program in ways we must seek to understand. Emergent properties are visible only when considering the program as a whole.
- Related to this is ensuring root causes are understood. Such root causes should be viewed as not acting elsewhere in the program nor are they necessarily subject to recurrence at a later stage.
- Recognize stakeholders do not exist in isolation. 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.
- Understand traditional project control systems control nothing, but rather act to inform[10] 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[11]. Also recognize

[9] Law of requisite variety from cybernetics
[10] Estimating uncertainty and measuring variance
[11] National Academy of Construction Executive Insight, “Foundations for Success”

the broader environment often acts to constrain or otherwise dictate the actions that individuals can or choose to take. Leadership is important.

- Recognize the key points of leverage in large complex programs (shown in Table 2 in order of significance).
- Meaningfully deploy strategies for leverage (shown in Table 3) to guide the program to its desired outcomes.

Table 2 **Key Leverage Points in Large Complex Programs**
1. Business and environmental context in which the industry, enterprise, or program exists
2. Strategic business outcomes (SBOs) the program is to deliver
3. Who makes the rules (shareholders, stakeholders, regulators)
4. Rules that impact program execution (resources, constraints, incentives, penalties, latent risks, and opportunities)
5. Information flows (leading insight, contemporaneous, lagging; information vs noise)
6. Logistical flows (supply chain; management/sequencing/coordination of engineering and construction)
7. Advantaging negative feedback loops (stabilizing)
8. Limiting/controlling positive feedback loops (drive multi-finality)
9. Monitoring/controlling assumption migration
10. Fixed parameters, standards, regulations

Table 3 **Strategies for Leverage**[12]
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 (The law of unintended consequences).
Identify critical points of weakness or control and act upon them to reinforce or retard change.
Decentralize program and project control to retain overall control on large complex programs.
Resist changes unless full program impacts are understood.
Do not remove or impose constraints without understanding why they exist 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.”[13]
Set outcomes. They allow for feedback.
Transparent broad distribution of information leads to good outcomes.[14]
Value time and timing.

[12] Adopted from De Rosnay “The Ten Commandments of the Systemic Approach”

[13] 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.

[14] Knowledge is most powerful if everyone has it.

Conclusion

Large complex programs are not well served by traditional PM theory. Instead, they require a significant change in perspective. The nature of these programs more closely resembles open systems, which are defined as part of General Systems Theory.

References

L. von Bertalanffy, *General Systems Theory: Foundations, Development, Applications.* G. Braziller, Inc., New York, 1968.

de Rosnay, Joel, *The Macroscope: A New World Scientific System*, 1979.

A. Montuori, "General Systems Theory," *International Encyclopedia of Organization Studies*.

A. Montouri, "Systems Approach," *Encyclopedia of Creativity*, 2011.

R. Prieto, National Academy of Construction *Executive Insights*, "Foundations for Success," July 2020 (https://www.naocon.org/insights/).

R. Prieto, "Generalized Analysis of Value Behavior over Time as a Project Performance Predictor," *PM World Journal*, Vol. I, Issue III, October 2012.

R. Prieto, "On the Subject of Black Elephants," *PM World Journal*, Vol. IX, Issue VII, July 2020.

R. Prieto, "Theory of Management of Large Complex Projects."

Senge, P., *The Fifth Discipline,* New York: Doubleday, 1990.

B. F. Van Dyk, "A Systems Thinking Assessment of Project Management," 2002.

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