Quantum Project Management, Large Complex Projects, and Entanglement [1]

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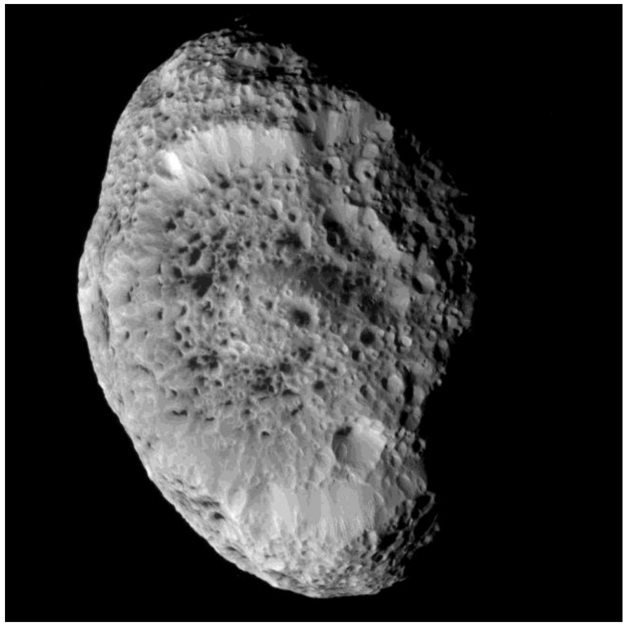
Introduction

In Quantum Project Management[i] I continued a journey which has spanned several decades as I first studied the unacceptably high "failure" rates of large complex projects, identified some root causes and suggested various focus areas[ii] to address the observed deficiencies. Along that journey I observed that classical project management theory failed us at scale and complexity, constrained by its founding grounded on straight-forward, decomposable projects that were well-bounded. At various points along that journey, I compared what needed to happen as being analogous to the break in thought and theory that occurred as both quantum theory and relativistic theory emerged in the physics domain. I suggested that a new theory of project management[iii] needed to emerge and suggested some of the analogies which linked the required elements of this new theory even more closely to the transformations that quantum and relativistic theories brought to classical physics.

While this journey began with a focus on scale, today it is focused on complexity and scale. Along the way the importance of system thinking became even more apparent as did the open systems nature of large complex projects. Stakeholders, and their stakeholders, were ever more important elements in the open systems context which is the nature of all quantum systems and in effect were a large part of the spacetime[iv] in which a project is set. This spacetime, or surrounding ecosystem if you will, is highly determinative of ultimate project success or failure, and as such the behaviors and futures of the project and ecosystem are intimately entangled.

This entanglement is something witnessed in quantum systems and importantly is the value adding property in quantum computing[v]. In larger systems, systems at scale, there had been an open question as to whether the effects of entanglement would be measurable and observable. This open question has now been addressed in observations related to the chaotic orbit of Hyperion, one of the moons of Saturn, where its chaotic orbit can be described as resulting from the combined consideration of that moon, the dust and photons striking it.

[1] How to cite this paper: Prieto, R. (2024). Quantum Project Management, Large Complex Projects, and Entanglement, PM World Journal, Vol. XII, Issue VII, July 2024.



Hyperion; Nasa

The Quantum Analogy

In quantum mechanics we describe quantum properties in the form of a wave function, represented by Ψ. This can be thought of as the probability distribution associated with a particular behavior or property such as spin. In large systems it had been assumed that the combined individual randomness would average out over time and be described by a more classical description. This, however, is not necessarily the case as was observed by studying the chaotic orbit of Hyperion. This chaotic orbit is better understood by considering the behavior of the larger system which Hyperion is part of, one including that moon itself together with the dust and photons striking it.

This can be described such that:

$$\Psi_{Observed} = \Psi_{Moon} + \Psi_{Dust} + \Psi_{Photons}$$

The interaction of dust and photons with the moon causes their wave functions to become entangled and it is this entanglement that results in the complex and chaotic orbit we observe. This particular type of entanglement is called Chaos Entanglement and systematically generates chaotic dynamics by entangling multiple stable linear systems such as the moon, dust and photons.

The entanglement functions create artificial chaotic behavior in each subsystem (moon, dust, photon), resulting in a chaotic overall system. In other instances, chaos entanglement opens possibilities for engineering applications, such as chaos-based secure communication. In the world of large complex projects chaos is not welcomed and we often fail to estimate the effects of entanglement.

Entanglement in Large Complex Projects

Projects can be theoretically described by a wave function. In a bounded environment (such as what Gantt posited), one isolated from any external influences, it behaves classically, and the wave function collapses to what conventional project management theory describes.

Entanglement: Entanglement is a phenomenon where the properties of two or more objects become correlated in such a way that the state of one object cannot be described independently of the state of the other(s). Changes to one entangled object will instantaneously affect the others, regardless of the distance between them. We witness this correlation at scale in LCP and often observe, in hindsight, the deleterious effects of second and third order coupling.

The whole of the LCP can no longer be described just by the sum of its parts. Importantly, the LCP must be looked at in a broader system of systems context, where the effects of entanglement become even more significant. System of Systems (SOS) problem sets have no singular deterministic solution.

This entanglement can extend beyond the proper boundaries of the LCP itself, encompassing elements of the surrounding ecosystem.

But projects, especially large complex projects (LCP), are not isolated from external influences but rather entangled, and as a result the correct wave function includes both the classical description of the project as well as the wave functions associated with each of the external influences, show below as stakeholders but can include broader external factors.

We can write this as:

$$\Psi_{\text{LCP Actual}} = \Psi_{\text{LCP Classical/Bounded}} + \Psi_{\text{Stakeholder 1}} + \Psi_{\text{Stakeholder 2}} + \Psi_{\text{Stakeholder 3}} \;\ldots\; \Psi_{\text{Stakeholder } n}$$

This combined wave function for this open system does not collapse to its classical outcome but rather to something else. If the external influences are persistent and significant chaos is possible as we saw with Hyperion.

Sources of Entanglement

Interdependencies, interactions, and complexities arise when managing large complex projects. These projects involve multiple stakeholders, intricate processes, and various subsystems. As a result, they become entangled due to dependencies, uncertainties, and dynamic interactions.

Traditional sources of entanglement include:

- **Influencing Flows –** These arise from the surrounding spacetime or ecosystem in which the project resides and is an integral part of. These flows very much epitomize the open systems nature of large complex projects and are characteristic of projects with multiple stakeholders.
- **Scope Changes** - Frequent scope modifications can lead to entanglement. When requirements evolve, it affects project components and schedules. These scope changes may arise internally, especially if strategic business objectives (SBOs)[vi] have not been clearly articulated, agreed to and continuously communicated. They also arise from outside the project from any one of the plurality of stakeholders acting directly or indirectly on the project.
- **Resource Constraints**: Limited resources (such as skilled labor, materials, or equipment) can cause bottlenecks and delays, leading to entanglement. Constraints[vii] may be direct or coupled (indirect) and can include temporal coupling.
- **Communication Challenges**: Poor communication among project teams, stakeholders, and contractors can create misunderstandings and conflicts. Continuous alignment[viii] is essential to minimize unneeded entanglements.
- **Risk and Uncertainty**: Unforeseen risks, market fluctuations, and external factors introduce complexity and entanglement. Risk models must reflect the fat tails[ix] associated with large complex systems.

Conclusion

In Hyperion we saw the chaotic behavior which results from persistent interaction with a large number of small entanglements. Collectively they are small but impactful although just a fraction of Hyperion itself. In large complex projects, the cumulative impact of all stakeholders, all externally derived entanglements, can be even more significant.

Quantum Project Management provides a robust framework for understanding and gaining new insights and management strategies for large complex projects.

About the Author

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Bob Prieto is Chairman & CEO of Strategic Program Management LLC focused on strengthening engineering and construction organizations and improving capital efficiency in large capital construction programs. Previously Bob was a senior vice president of Fluor focused on the development, delivery and turnaround of large, complex projects worldwide across the firm's business lines, and Chairman of Parsons Brinckerhoff.

Bob's board level experience includes Parsons Brinckerhoff (Chairman); Cardno (ASX listed; Non-executive director); Mott MacDonald (Independent Member of the Shareholders Committee); and Dar al Riyadh Group (current)

Bob consults with owners of large, complex capital asset programs in the development of programmatic delivery strategies encompassing planning, engineering, procurement, construction, financing, and enterprise asset management. He has assisted engineering and construction organizations improve their strategy and execution and has served as an executive coach to a new CEO.

He is author of nine books, 950 papers and National Academy of Construction Executive Insights, and an inventor on 4 issued patents.

Bob's industry involvement includes ASCE Industry Leaders Council, National Academy of Construction and Fellow of the Construction Management Association of America (CMAA). He serves on the New York University Abu Dhabi Engineering International Advisory Council and previously served as a trustee of Polytechnic University and the Millennium Challenge Corporation Advisory Board. He was appointed as an honorary global advisor for the PM World Journal and Library.

Bob served until 2006 as one of three U.S. presidential appointees to the Asia Pacific Economic Cooperation (APEC) Business Advisory Council (ABAC). He chaired the World Economic Forum's Engineering & Construction Governors and co-chaired the infrastructure task force in New York after 9/11.

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