
Physics of Projects

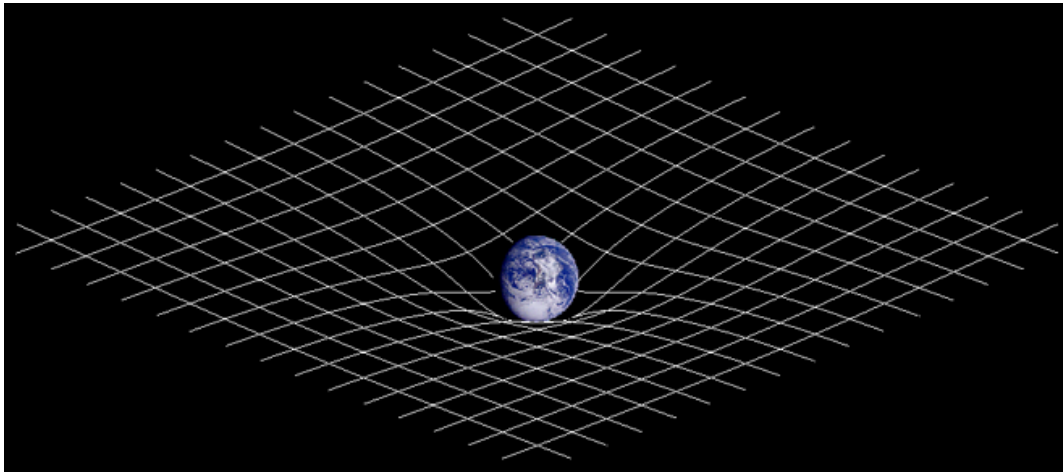
Bob Prieto

My last paper¹ posed the question as to whether it is time to rethink project management theory, at least as it applies to the universe of large projects. Based on the number of emails and discussions that this has triggered I feel more confident than before that this is a question best answered “YES”. In thinking about this question and precedents for development of new fundamental theories to address special or radically different circumstances I was struck by the development of new fundamental theories in the world of physics.

In that field, classical theory, sometimes referred to as the theory of mechanics, were underpinned by Newton’s Laws of Motion. These laws can be described as encompassing an inertial frame of reference and a deterministic nature in addition to the stalwart equation of $F=ma$ that we are all familiar with. But as time moved on, physicists realized that these theories did not adequately describe the universe around us as we considered extremes relative to our more common experiences. This led to the development of neo-classical theories that include quantum mechanics with its characteristics of a probabilistic world, that forces us to abandon the notion of precisely defined trajectories through time and space, and uncertainty, that says we can’t know location and velocity precisely at the same time. This consideration of the universe in extremis also led to Einstein’s special theory with its emphasis on relative frames of reference and the concept of spacetime (space and time should be considered together and in relation to each other). Neo-classical theory is best represented by the well know equation $e=mc^2$.

Table 1 highlights some of the differences between classical and neo-classical theory and suggest some comparisons to the universe of large projects.

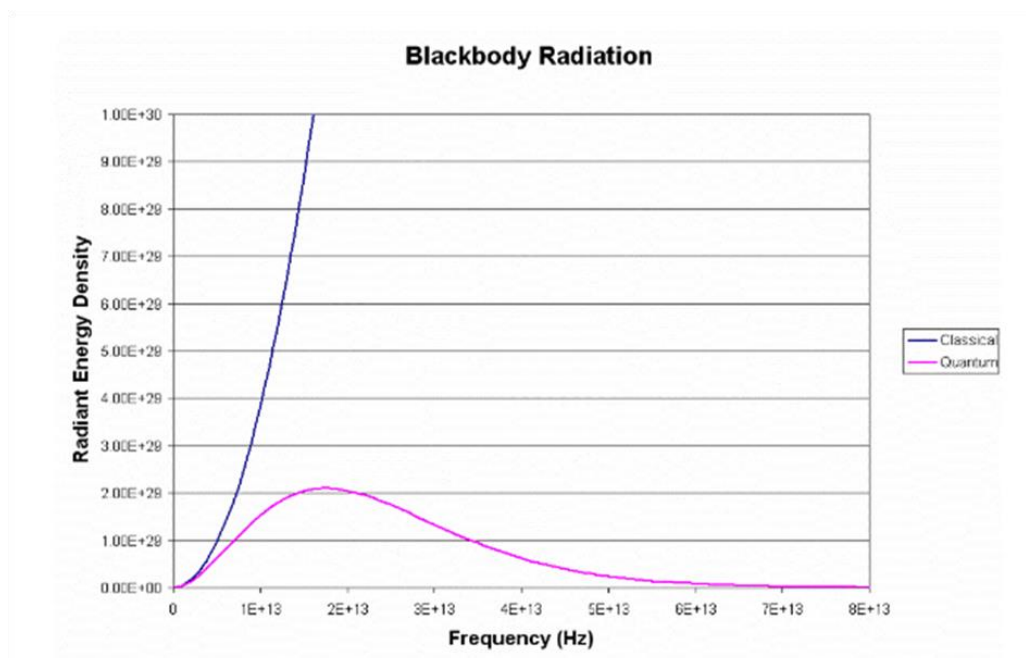
¹ 1. Is it Time to Rethink Project Management Theory?; PM World Journal; March 2015



Classical and neo-classical theories were both focused on the same problem. If the state of a dynamic system is known initially and something is done to it, how will the state of the system change with time in response?

This is analogous to what we are trying to determine in project management.

In the world of physics, classical theory breaks down at scale. This is best demonstrated when looking at system performance (represented by Blackbody Radiation) which is over predicted by classical theory. Scaling (frequency and energy grow) leads to lower unit performance (energy density).



So how does this compare to classical PM theory in the world of human scale projects as opposed to those found at scale? In classical PM theory projects are seen as “temporary endeavors” versus enduring outcomes. Project management is viewed mechanistically (similar to classical theory in physics). This mechanistic view encompasses applying knowledge, skills, tools and techniques and accomplishing the project in a stepwise fashion (similar to the deterministic world we experience in classical physics). These steps in classical PM theory include initiating, planning, executing, monitoring & controlling, and closing.

In classical PM theory, governance largely imposes constraints on a project as opposed to providing an enabling context. Frames of reference are largely fixed versus being relative to all that is acting on the project, including stakeholders (internal and external) with radically different frames of reference. Organizational strategy is largely viewed as providing guidance and direction versus driving a project to achievement of Strategic Business Objectives (SBOs). This opens the door to varying (even if only slightly) interpretations of SBOs.

Classical PM theory breaks down at scale. Large scale project performance is over predicted by classical PM theory and these scaling effects lead to poorer performance outcomes. Two out of three large projects fail! In large projects, frames of reference are relative and change over the project’s lifetime, not just the project delivery lifetime. Probability and uncertainty take on greater importance and classical modeling breaks down. Time and timing take on dominant roles. We are no longer in the equivalent of Newton’s world under an apple tree.



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The creation of neo-classical physics theories to describe behaviors in extremis is analogous to the challenge that PM theory faces today. Scale matters. Scale reveals the presence of complexities not otherwise seen. We are forced to consider multiple changing frames of reference. Probabilities provide for extreme behaviors and uncertainty opens the door to multiple project paths and outcomes. Finally, time (and timing) are an integral part of everything.

So what must a neo-classical PM theory address?

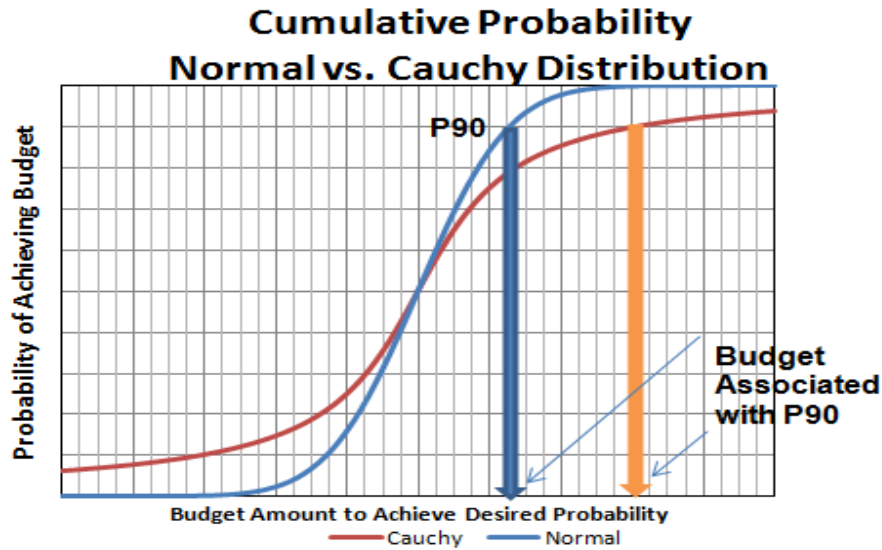
Neo-classical PM theory must address uncertainty within the owner's scope of control, governance models, owner readiness and planning biases. Uncertainty within the owner's scope of control must particularly focus on the articulation, agreement and continuous communication of SBOs. Governance models, geared to the universe of large projects that is the focus of neo-classical PM theory must reflect the inherent complexity of these projects as well as the changing nature of large projects. These models must enable, seek and support opportunities not just impose constraints. They must be focused on achieving strong and sustained internal stakeholder alignment, often overlooked in smaller projects, and they must build aligned partnerships not adversarial failures.

Neo-classical PM theory must test owner readiness similar to how we test project readiness and planning biases such as optimism bias created by Kahneman's² "framing questions" must be thoroughly identified and checked.

Next, neo-classical PM theory must address probability and improbability³, which do not behave "normally" as complex systems begin to look like financial and natural systems where catastrophe's are a reality. Perhaps some of the weakness we see in the application of classical PM theory in large projects is associated with inadequate or inappropriate baseline plans. Are the baselines we manage to built on weak foundations. If we consider a more "catastrophic" distribution of project performance such as that associated with a so-called fat tail distribution such as a Cauchy distribution our view of the world and how it behaves is greatly altered similar to what was seen in the world of physics as theory migrated from classical to neo-classical. The project with a P90 confidence level under a Monte Carlo analysis using a normal distribution that is expected to cost \$6.2 billion rises to \$8 billion at a similar confidence level under a Cauchy distribution. Perhaps we should not be surprised by failure!

² Thinking, Fast and Slow; Daniel Kahneman; 2011

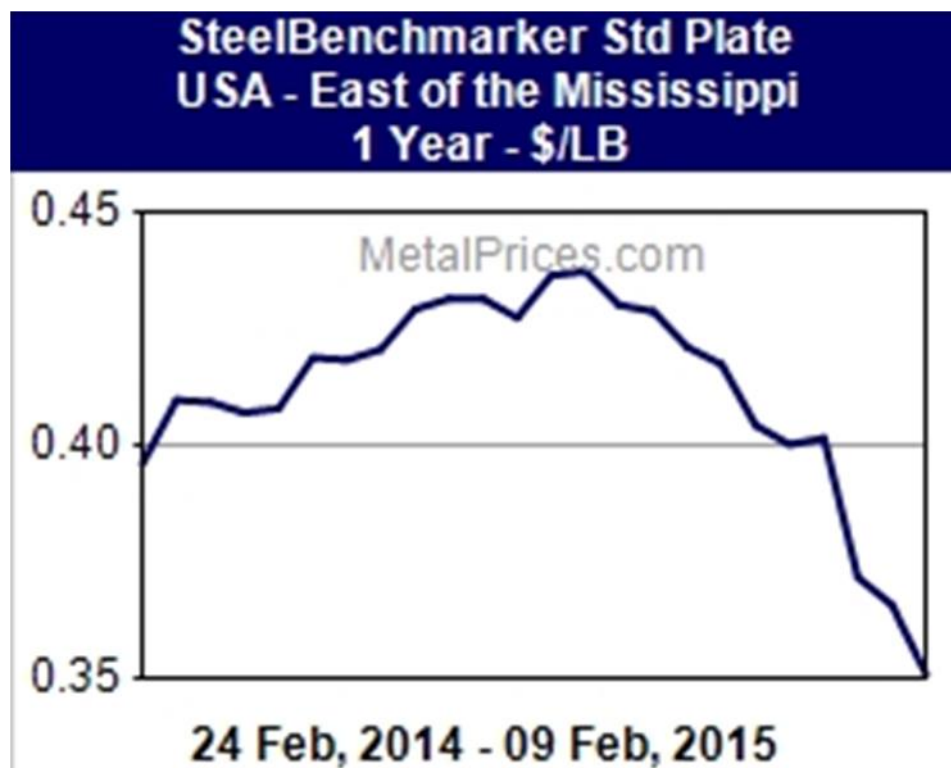
³ The Improbability Principle: Why Coincidences, Miracles, and Rare Events Happen Every Day; David J. Hand; 2014



Two other points with respect to probability and improbability are worth noting as we move to a neo-classical world. The first deals with our views of the risks to be managed. It is not unusual for low frequency, high impact risks to fall out of risk planning and management since their likely contribution to project outcome is judged to be incidental. Yet it is often these very risks which contribute to project failure. Let's consider the case of a 5 sigma risk in our "normally" modeled project. It has a 1 in 3.5 million chance of occurring. Not including a contribution to likely project cost is not surprising. But now let's think about that same 5 sigma risk if we build our baseline using a Cauchy distribution. It now has a 1 in 16 chance of happening and given its potential high impact it is very much a subject of our attention. (Even more interesting is a 30 sigma events which "normally" has 1 chance in 2 times ten to the 197th power but with a fat tail distribution it now has a 1 in 94 probability.

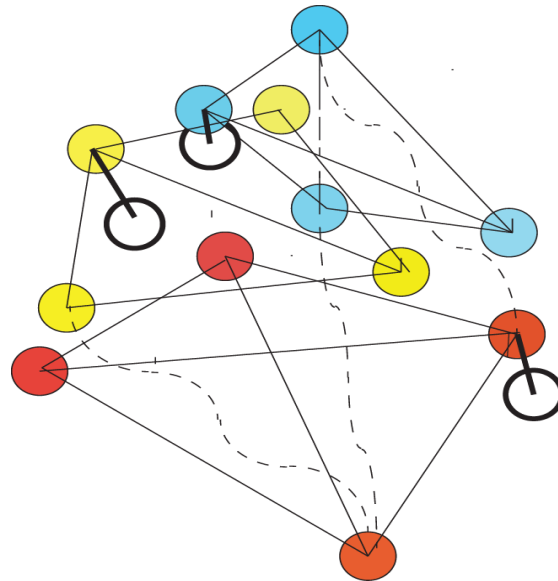
Probability of the Improbable		
	Normal	Cauchy
5 sigma event	1 in 3.5 million	1 in 16
30 sigma event	1 in 2.0×10^{197}	1 in 94

The second point with respect to probability and improbability deals with consideration of volatility (think uncertainty). During a recent one year period we saw steel price volatility approaching 20%.



Neo-classical PM theory must also address uncertainty outside the owner's and industry's sphere of control. This is contrasted with uncertainty within the owner's control previously described. This second form of uncertainty derives from the extended timeframes and inherent complex web of inter-relationships that may not be readily apparent. We see this in assumption migration (assumptions sufficiently fixed for shorter duration projects move more than expected over extended project durations and such movement makes a difference); implicit assumptions that we don't even recognize that we have made (we must make these explicit in neo-classical PM); and constraint coupling which often is a second or third order phenomena (think about how the US foreign exchange rate has impacted oil price, CAPEX and national economies)

Complexity is an inherent feature not only of the large projects that neo-classical PM theory should be the focus of but also the 50,000 to 100,000 activity project schedules we develop to manage them. In this neo-classical world we need to measure complexity, as a system level property, and ensure our plans have sought to minimize this complexity. We must constantly assess the potential for "white space" risks in this universe of large projects recognizing that Black Swans nest and breed in these white spaces.



The extended time frames of large projects requires a PM theory that in many ways starts earlier than classical PM theory addresses while recognizing that in the universe of large projects a project is not sufficiently defined in terms of initial delivery but rather demands a life cycle approach to provide the improvements in capital efficiency that owner's are clamoring for.

Neo classical PM theory must recognize the dynamic and ever changing nature of the environment in which large projects occur and provide for dynamic planning, re-baselining and assumption tracking. In this world of execution in a changing environment, owner's must accept the impacts of disruption and avoid contributing to it.

Large projects are dynamic, often chaotic, systems in a changing world of constraints and opportunities. We must recognize that general management theory itself has changed since PM theory was first conceived.

Table 1 Comparison of Physics Theories as Analog for Comparison of PM Theories		
Classical Physics	Neo-Classical Physics	Neo-Classical PM
Deterministic	Relativistic	Relativistic
Low Energy	High Energy	Many concurrent activities
Human Scale	Very Large Scale	Very Large Scale
Action from Force	Action at Distance (quantum entanglement)	System level interactions not well understood
Independent of Frame of Reference	Frame of Reference Matters	Frame of Reference Matters
Time independent	Spacetime (physical properties and time influence each other)	Logistics and durations shaped by schedule and relative activity levels
Cartesian space	Curvature of space	Relational space and activities (each highly influences the other)
What we can see	Black Holes, dark matter, dark energy	The unseen in complexity (Black Swans; constraint coupling; white space risks; assumption migration; dynamic risks)

About the Author



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

Bob is a member of the ASCE Industry Leaders Council, National Academy of Construction, a Fellow of the Construction Management Association of America, a member of the World Economic Forum Global Agenda Council and several university departmental and campus advisory boards. Bob served until 2006 as a U.S. presidential appointee to the Asia Pacific Economic Cooperation (APEC) Business Advisory Council (ABAC), working with U.S. and Asia-Pacific business leaders to shape the framework for trade and economic growth and had previously served as both as Chairman of the Engineering and Construction Governors of the World Economic Forum and co-chair of the infrastructure task force formed after September 11th by the New York City Chamber of Commerce. Previously, he served as Chairman at Parsons Brinckerhoff (PB).

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