Delivering Next Generation Nuclear Power: The Project Management Challenge Remains[1]

Bob Prieto

Global events are reshaping energy flows and driving a rethink of what the future power fleet will look like in the short, medium, and longer term. Interest in renewables has strengthened in response to both the challenges to traditional energy supplies as well as decarbonization efforts to address global climate[2] change. Hydrogen as a fuel, ultimately dependent on a strong nuclear generation component, has gained traction with major projects focused on its transport and storage.

Significantly, the waning interest in nuclear has been reversed with new projects being considered even in countries which had written it off as a future source just a few years ago. Today there is growing recognition that nuclear must be a significant part of the future power fleet, especially as interest in hydrogen grows.

Nuclear technology and solutions have advanced significantly over the last decade, spurred on by the 2011 events at Fukushima. Among these advances has been the development of Small Modular Reactors (SMRs) that address the loss of power, safe shutdown and other concerns that were underscored at Fukushima. Additionally, SMRs represent the continued shift in complex projects to greater modularity, standardization, and off-site construction, capturing the benefits of a manufacturing environment. A first such SMR has received design approval from regulators in the US.

The focus of this advisory article is to begin to explore the project management challenges that SMR deployment will have to address if it is to avoid the spiraling costs and schedules of the last generation of nuclear power plants. It draws on my experience at the outset of my career on the design and licensing of a standardized nuclear power plant driven by many of the same concerns that today's SMRs seek to address. It further draws on my experience in troubleshooting underperforming large complex projects including more recent forensic analysis of a significant nuclear project that was ultimately abandoned.

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[2] Prieto, R. (2021). Reversing Global Warming, PM World Journal, Vol. X, Issue III, March. https://pmworldlibrary.net/wp-content/uploads/2021/03/pmwj103-Mar2021-Prieto-Reversing-Global-Warming.pdf

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The advice that follows is not intended to be comprehensive, but rather to call out some of the top-of-mind project management challenges that will have to be met more successfully than we have done in the past.

Defining the SMR team

The delivery of an SMR will require the tight integration of several entities. The nature of the relationships may vary but the inherent capabilities and respective responsibilities will be present irrespective of contractual and organizational relationships. For purposes of this advisory article, they are defined as:

- SMR vendor
- Balance of Plant (BOP) contractor
- Systems Integrator
- Program Manager
- Owner
- Regulator
- Stakeholders

SMR Delivery – A Systems[3] Engineering Challenge

SMRs, like all large complex projects, requires a systems engineering mindset[4] [5] in order to address inherent complexity[6] and the inevitable emergence associated with such projects. This is an area where the project management profession must do better and expand its systems, processes, tools and most importantly, training. A key component of the systems engineering mindset as it relates to SMR delivery is systems integration.

SMR's will require comprehensive systems integration with this taking on even greater importance in the initial implementations where emergence is all but ensured. Systems integration is an essential element in delivery of large complex projects and one which has challenged many nuclear projects in the most recent period. While I have shown this

[3] Prieto, R. (2020) Systems Nature of Large Complex Programs; PM World Journal, Vol. IX, Issue VIII, August https://pmworldlibrary.net/wp-content/uploads/2020/07/pmwj96-Aug2020-Prieto-Systems-Nature-of-Large-Complex-Programs.pdf

[4] Prieto, R. (2020). Application of Systems Lifecycle Processes to Large, Complex Engineering and Construction Programs; PM World Journal, Vol. IX, Issue X, October https://pmworldlibrary.net/wp-content/uploads/2020/09/pmwj98-Oct2020-Prieto-Application-of-Systems-Lifecycle-Processes-to-Large-complex-programs.pdf

[5] Prieto, R. (2020). Systems Nature of Large Complex Programs; PM World Journal, Vol IX, Issue VIII, August. https://pmworldlibrary.net/wp-content/uploads/2020/07/pmwj96-Aug2020-Prieto-Systems-Nature-of-Large-Complex-Programs.pdf

[6] Prieto, R. (2017), Complexity in Large Engineering & Construction Programs, PM World Journal, Vol. VI, Issue XI, November. https://pmworldlibrary.net/wp-content/uploads/2017/11/pmwj64-Nov2017-Prieto-complexity-in-large-engineering-construction-programs.pdf

as a separate function in the preceding section, it is most assuredly not so. The function must be an integral role to one of the major project delivery organizations.

There are in reality only three candidates for providing systems integration on a SMR project:

- SMR vendor,
- Owner, or
- Balance of Plant contractor

Reflecting back on the beginnings of the commercial nuclear industry, the first of a kind nature of these plants, and the observed management deficiencies such as seen in the abandoned VC Summer project, would argue for this role to be fulfilled by the SMR vendor. But unlike the beginnings of the commercial nuclear industry, SMR vendors will be seeking to utilize an asset light model with manufacturing performed on a contract basis based on SMR provided designs.

This systems integration role, whether provided by the SMR or more likely the owner, will require the definition of the **critical few** interfaces[7] between SMR and BOP contractor. This focus on the **critical few** is especially important if the SMR is to achieve its stated safety outcomes without reliance on the BOP.

The owner[8] is not relieved of his traditional project management responsibilities but his role in some ways is shaped by the approach to systems engineering that is deployed and the nature of his contract for balance of plant.

In addition, the owner requires a strong project management oversight (PMO)[9] capability incorporating strong materials and in-shop observation and quality assurance. While also important on a nuclear project, they will be especially critical in both assuring the inherent safety that the SMR is to bring as well as serving as a leading indicator of any emerging project delivery challenges.

SMR delivery demands strong project foundations

The modularization and offsite fabrication of the SMR in many ways simplifies some elements of project delivery but not the management challenges inherent in the delivery of a complex project deploying new design concepts and technology.

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[7] Prieto, R. (2021). Rethinking Interface Management, PM World Journal, Vol. X, Issue VIII, August https://pmworldlibrary.net/wp-content/uploads/2021/08/pmwj108-Aug2021-Prieto-Rethinking-Interface-Management.pdf

[8] National Academy of Construction Executive Insights, Owner Readiness https://www.naocon.org/wpcontent/uploads/Owner-Readiness.pdf

[9] 6 PMO & the Tollgate Process; PM World Journal; May 2013; https://www.researchgate.net/publication/272505052_PMO_the_Tollgate_Process

Getting the foundations of the project right are essential. Alignment among all parties must begin with a clear, agreed to articulation of the project's strategic objectives[10]. This will be especially important in initial projects as those objectives may vary among the various parties (owner – cost, schedule; SMR – technology demonstration, commercialization; BOP – manageable risk appetite and risk adjusted compensation). These agreed to objectives must be kept front and center across all parties involved.

All projects are founded on assumptions[11] including many that are never recorded or tracked. Delivery of SMRs will be no different and the role of assumptions in initial projects is further heightened based on novelty and changed contextual frameworks. Assumption tracking is essential and must go beyond current practices, particularly as influenced by regulatory or stakeholder interactions. Assumptions with respect to supply chain[12] [13] performance, especially with respect to adherence to schedule and quality control, warrant special attention. This last point is especially relevant given weaknesses in the nuclear supply chain that have arisen as new project volumes have declined.

SMRs modify traditional project flows

The delivery of an SMR project will require special attention to project "flows." These flows include not only the traditional logistical and supply chain flows we experience in delivery of complex capital construction projects but also flows related to new and different information and regulatory constructs. The integrated nature of the SMR itself creates both advantages and disadvantages in information flows, limiting interfaces between SMR and BOP but at the risk of creating an unsatisfactory black box if carried to an extreme.

Interface management is essential given the intended standardization benefits that an SMR is intended to represent. Interfaces may be classified with each class requiring different management techniques and tools. These classes can be broadly thought of as:

- those internal to the SMR configuration, cutting across multiple manufacturing partners and modules

[10] National Academy of Construction Executive Insights; The Importance of Strategic Business Objectives https://www.naocon.org/wp-content/uploads/The-Importance-of-Strategic-Business-Objectives.pdf
[11] Prieto, R. (2016). Management of Assumption Infatuation in Large Complex Projects, Vol. V, Issue IV, April. https://pmworldlibrary.net/wp-content/uploads/2016/04/pmwj45-Apr2016-Prieto-Management-of-Assumption-Infatuation-in-Large-Complex-Projects.pdf
[12] Prieto, R. (2021). Capturing Opportunities in Procurement Management on Major Capital Programs, PM World Journal, Vol. X, Issue XII, December. https://pmworldlibrary.net/wp-content/uploads/2021/12/pmwj112-Dec2021-Prieto-Capturing-Opportunities-in-Procurement-Management-on-Major-Capital-Programs.pdf
[13] National Academy of Construction Executive Insights; Procurement Management in Large Complex Programs https://www.naocon.org/wp-content/uploads/Procurement-Management-in-Large-Complex-Programs.pdf

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- those that arise along the SMR supply chain that affect physical, metallurgy and chemistry, strength (particularly welds), and other performance attributes
- those that touch the SMR from the balance of plant both directly and indirectly
- those associated with the physical environment, as they impact, directly or indirectly, the SMR or BOP
- those broadly associated with ESG[14] factors and risks
- those associated with all other enterprise risks[15] especially as they may impact the performance of key project participants such as Owner, SMR vendor, and BOP contractor.

SMRs change stakeholder relationships

Delivery of an SMR project must shift the nature of the relationship and interaction with regulatory bodies. This will require an increasingly performance based regulatory mindset which is yet to be demonstrated. Reasonably expected modifications within the SMR during fabrication are to be anticipated and pre-agreement on tolerances is particularly important if extensive re-review of SMR designs is to be avoided.

Stakeholder engagement[16] is always a significant challenge on large complex projects, with the prior generation of commercial nuclear projects experiencing some of the greatest impacts. SMRs offer the potential to turn challenge into opportunity, highlighting their climate advantages and role in a broader green energy system. Greatly reduced emergency planning boundaries (site boundary vs. ten miles) will also act to reduce some stakeholder concerns and risks.

Thoughts on delivering an SMR project

The organizational and contracting arrangements for delivery of an SMR project will evolve as market factors change and experience is gained. It is important to think about what initial delivery organization and contracting relationships should be. The advice that follows is intended as a starting point for management of an SMR project and will vary with the respective strengths of the participating organizations.

The project team is envisioned to consist of three principal organizations:

[14] Prieto, R. (2022). Environmental, Social and Governance Risks in the Engineering and Construction Sector, PM World Journal, Vol. XI, Issue VI, June. https://pmworldlibrary.net/wp-content/uploads/2022/05/pmwj118-Jun2022-Prieto-ESG-Risks-in-the-Engineering-and-Construction-Sector.pdf
[15] Prieto, R. (2022). Enterprise Risk Management in the Engineering and Construction Industry, PM World Journal, Vol. XI, Issue V, May. https://pmworldlibrary.net/wp-content/uploads/2022/05/pmwj117-May2022-Prieto-Enterprise-Risk-Management-in-Engineering-and-Construction-Industry.pdf
[16] Stakeholder Management in Large Engineering & Construction Programs; PM World Today; October 2011 https://www.researchgate.net/publication/273119019_Stakeholder_Management_in_Large_Engineering_Construction_Programs

- SMR vendor
- BOP contractor
- Owner

SMR Vendor

The SMR vendor would serve as a key partner with an owner-based systems integrator for the project in addition to providing the SMR itself. The SMR contract can be thought of as consisting of two elements, one related to the manufacturing of the SMR and provision of power rated modules and the second related to its systems integration support role.

With respect to manufacturing of the initial SMRs, building a qualified supply chain will be a significant effort and, in some ways, may represent one of the most significant risks faced. Contract provisions related to provision of the SMR will have to carry appropriate escalation clauses to mitigate material and supply chain risks. The potential for government provided research and development or other funds may shape contract form but in the most basic sense costs include a licensing component, associated with recovery of investments made to develop and license the SMR, and manufacturing costs where escalation and supply chain risks reside. Manufacturing related costs may be contracted for either on:

- a fixed price basis with escalation and other agreed to adjustments, or
- an open book basis with agreed to target price, escalation and adjustment provisions, and incentive fee.

The systems integrator component of the SMR contract should be viewed as support to an overall systems integration role that will increasingly be undertaken by the owner. It should include, as a minimum:

- real time assumption tracking as it relates to the SMR design and manufacturing
- configuration management within the SMR battery limits
- management of the **critical few** interfaces between SMR and BOP described above (Prime responsibility will reside with the owner but the SMR vendor's role is critical)
- focus on minimizing rework[17], a significant cost and schedule driver
    - welding will be a critical management focus area

[17] Prieto, R. (2021). Rework in Engineering and Construction Projects, PM World Journal, Vol. X, Issue IV, April. https://pmworldlibrary.net/wp-content/uploads/2021/04/pmwj104-Apr2021-Prieto-Rework-in-Engineering-and-Construction-Projects.pdf

- regulatory interface either on behalf of the owner or as a strong component of the owner's regulatory team
- training of operations and maintenance staff for the owner's organization

The systems integration component would be envisioned as a reimbursable contract.

BOP Contractor

The BOP contractor's role would be to provide program management and the necessary site improvements, auxiliary buildings, and transmission interfaces. The integrated nature of SMRs eliminates the need for a separate turbine island, traditionally a major BOP component. Management of interfaces within the BOP scope would likely be the responsibility of the BOP contractor but could reside with the owner's systems integration role depending on the contracting approach the owner selects for the BOP. A single EPCM contract for the BOP would simplify and strengthen project delivery responsibilities.

In all instances the purchase of non-SMR long lead equipment and materials would be to the owner's account with support coming from the BOP EPCM.

Depending on owner capabilities the BOP role may extend into interfaces with stakeholders on behalf of the owner

Owner

At the end of the day responsibility for successful project delivery resides with the owner. While the BOP contractor would provide program management services the owner must be focused on program management oversight[18].

Prior experience has highlighted two owner organization characteristics which are detrimental to successful delivery of large complex projects:

- inadequate understanding of the owner's role and insufficient program management oversight (PMO) capabilities
- micromanagement and/or injection of personal preferences driving unnecessary or suboptimal design or construction changes

The owner of an SMR project must:

- put in place a strong PMO organization with added emphasis on:
    - materials quality assurance
    - manufacturing observations along the supply chain
    - independently assessing supply chain performance

[18] Program Management Audit Checklist
https://www.researchgate.net/publication/273118616_Program_Management_Audit_Checklist

- have an adequately staffed and robust systems integration organization focused on:
    - real time, whole of project assumption tracking
    - configuration management and change control across the entirety of the project
    - management of the **critical few** interfaces between SMR and BOP described above
    - focus on minimizing rework[19], a significant cost and schedule driver
    - regulatory interface with strong support from the SMR vendor
    - training of operations and maintenance staff in conjunction with the SMR vendor
- assure an overall program management organization, likely provided by the BOP contractor, is adequately staffed with world class resources
    - for a first of a kind SMR deployment this may best be done by the BOP EPCM where these resources typically reside, with the owner serving as PMO
    - clarity on relationship between Owner/systems integrator, BOP EPCM/Program Manager and SMR vendor roles are essential especially as it relates to directing and approving change
- Ensure enterprise risks of all primary parties are visible and being managed.
    - failure of a major supplier is a project failure in progress

Concluding thoughts

This advisory article is far from comprehensive but is intended to stimulate thinking into how we can better deliver the next generation of nuclear power projects with a focus on those using small modular reactor (SMR) technology. Questions remain on the relationships between owner, SMR vendor and BOP contractor. Partnering will be essential and the potential for a consortium structure will be highly dependent on the specific parties involved.

[19] Prieto, R. (2021). Rework in Engineering and Construction Projects, PM World Journal, Vol. X, Issue IV, April. https://pmworldlibrary.net/wp-content/uploads/2021/04/pmwj104-Apr2021-Prieto-Rework-in-Engineering-and-Construction-Projects.pdf

About the Author

Bob Prieto

Chairman & CEO
Strategic Program Management LLC
Jupiter, Florida, USA

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 Cycle Analysis in the Capital Assets Industry”, “Capital Efficiency: Pull All the Levers” and, most recently, “Theory of Management of Large Complex Projects” published by the Construction Management Association of America (CMAA) as well as over 800 other papers and presentations.

Bob is an Independent Member of the Shareholder Committee of Mott MacDonald and a member of the board of Dar al Riyadh. He is a member of the ASCE Industry Leaders Council, National Academy of Construction, a Fellow of the Construction Management Association of America, and member of 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. He is a member of the Millennium Challenge Corporation advisory board where he had previously served. He 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) and a non-executive director of Cardno (ASX).

Bob serves as an honorary global advisor for the PM World Journal and Library and can be contacted at rpstrategic@comcast.net.

To view other works by Bob Prieto, visit his author showcase page in the PM World Library at https://pmworldlibrary.net/authors/bob-prieto/