EFCOG PROJECT MANAGEMENT WORKING GROUP

DESIGN MATURITY CONSIDERATIONS FOR DOE CAPITAL PROJECTS

WHITE PAPER

FY 2011

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Introduction and Executive Summary

A key objective of the Department of Energy is to be removed from the GAO High Risk List, by executing more effective project management and performance across the complex. Focused efforts, such as the revision of DOE Order 413.3B, have been made to develop improvement plans in the following areas:

- Management
- Oversight
- Accountability
- Compliance with Departmental Policies

On March 4, 2010, Deputy Secretary Daniel Poneman issued a policy statement regarding project management processes, which provided pointed guidance designed to improve the following topical areas of DOE project management:

- Project Size and Structure
- Project Team Staffing
- Funding Stability
- Project Peer Reviews
- Project Information Management
- Improving DOE Cost Estimates

In addition to the six criteria listed above, the letter also outlined policy regarding design maturity, charging OECM with determining the "sufficiency" of the design maturity, and using evaluations as a key parameter to determine whether to approve the project to proceed past CD-2 and into construction. The metric that DOE has set for project success is to maintain budget and schedule as set at CD-2, which is final design, through construction and project completion.

The two main facets of the policy are:

- Ensure that design maturity is commensurate with the size, duration, and complexity of the project.
- Ensure that design maturity at CD-2 limits changes to meet "success criteria", listed as less than 10% deviation from approved cost and schedule baseline.

While there is no "one-size fits all" program or philosophy that can be applied to all DOE capital projects due to the wide variation in size and technical complexity, this white paper is intended to document the issues and recommend approaches based on lessons learned and successful examples to aid in meeting the goals of the Poneman policy regarding design maturity. Specific tools are described, which if applied with the appropriate rigor, can provide project management with assurance that sufficient design maturity can be attained at CD-2, and aid in executing successful projects for DOE.

Size & Technical Complexity

DOE Order 413.3B was written to provide project management requirements for all DOE capital projects, from $50M administration buildings to the $12B Hanford Waste Treatment Plant. The breadth of size and technical complexity of the projects managed by DOE is enormous; developing specific guidance and requirements for ensuring design maturity cannot be a "one-size fits all" solution. Therefore, the relative size and complexity of the design for the project, and how that feeds into the acquisition strategy, is of paramount importance in ensuring the appropriate level of design maturity to underwrite project success.

DOE Order 413.3B requires the following:

- The design must be sufficiently mature at CD-2 to ensure project success.
- Annual peer reviews on projects valued at over $100M shall help determine adequacy of design maturity.
- Enhanced External Independent Reviews (EIR) shall be used to validate the performance baselines by incorporating industry standard practices and using the following tools:

    - Project Definition Rating Index (PRDI)
    - Technology Readiness Assessment (TRA)
    - Technology Maturation Plan (TMP)
    - GAO 12-Step Cost Estimating Process

As a result, a general correlation between size and technical complexity drives acquisition strategies between Design/Build and Design/Bid/Build, to help projects perform to the approved CD-2 baseline. The following generalizations can be made:

- **Design maturity tools will be applied to evaluate larger projects.** Projects over $100M will be subject to the full suite of screening and reviews using the prescribed evaluation tools in DOE Order 413.3B, aiding in ensuring acceptable design maturity.
- **Projects with lower technical complexity, such as administrative, warehouse, and general infrastructure facilities, can be executed via Design/Build acquisition strategies.** These types of projects do not incorporate unique or complicated technical principles into their designs. Proven, repeatable designs do not induce high levels of risk to projects; execution of construction is the driving factor in the success of these projects.
- **Projects with high technical complexity, such as R&D laboratory facilities and nuclear/chemical waste storage and processing facilities, require a strong focus on design maturity, testing, and should utilize a Design/Bid/Build acquisition strategy to mitigate risks.** Many of these projects require new or "one-of-a-kind" technologies to meet the mission need, where development and testing are required prior to making final design decisions. These projects tend to be longer in duration, and following a

Design/Bid/Build acquisition strategy in these cases would help in ensuring that the CD-2 baseline is reasonable and adequate, minimizing performance risk.

Design Maturity Evaluation Tools

There are many tools available to projects to evaluate and assess design maturity. Utilization of some of the tools/reviews is mandated by DOE Order 413.3B based on project size; others are driven by specific project needs. The following delineates the suite of tools that can be considered to support design maturity assessments:

Project Definition Rating Index (PDRI)

DOE 413.3B prescribes the use of PDRI to evaluate and assess scope definition for projects, to identify and mitigate risk. The process provides a comprehensive list of 73 elements of project scope, with heavy emphasis on Scope/Technical areas, which encompasses engineering design. Effective use of the PDRI process will yield good qualitative data with respect to the sufficiency of design maturity at a given point in time; typically PDRI is measured at each CD point. However, the relative simplicity of the checklist, and the subjectivity of the rating for each scope definition element requires strong project management and capable technical reviews to use the PDRI as a method for demonstrating sufficient technical maturity for a design.

Technical Readiness Assessment (TRA)

The TRA is a detailed tool used to assess how far a technology has been developed and proven. For technically-complex projects, such as R&D laboratory facilities or chemical/nuclear storage or processing facilities, elements of the design are frequently unproven, “one of a kind”, or in the development stage. These elements can be immature on their own, or the integration of these elements into the full design may be unproven. The TRA process will allow for projects to determine whether the elements and design can be proven on a pilot scale (Technology Readiness Level 6), such that the final design can minimize post CD-2 change orders due to scaling of technological to full-scale.

It is expected that the TRA process be used during conceptual and preliminary design phases, to support design development through CD-1 and CD-2.

Technology Maturation Plan (TMP)

A TMP is used to provide a plan to develop technologies to the TRL 6 level, which is demonstrated pilot-scale operation. Utilization of a TMP can be important in verifying design maturity. On more complex projects, various technologies or processes may be developed for the purposes of choosing a technology or process to incorporate into the design. TMP’s are used to frame testing of technologies and processes, such that the TRL can be assessed during alternative analysis activities during conceptual and preliminary design activities, and subsequently provide support for the basis of selection and incorporation into the final design at CD-2.

Independent Design Reviews

Independent design reviews should be performed prior to CD-1and CD-2, at the conceptual, preliminary, and final design stages. These reviews can provide feedback to the project with respect to meeting all mission needs, project and design requirements, and applicable codes and standards. Lack of design maturity can be delineated during these reviews, and be corrected prior to finalization of the design and project baseline at CD-2, or can be incorporated into the risk register for subsequent mitigation during construction and project completion phases.

Risk Register

The project risk register is another tool that can be used to define, delineate, and mitigate potential design maturity issues that can affect the successful completion of a project. The output of the other tools and processes discussed in this document should be collected and incorporated as input data to the project risk register. Ultimately, project management must be accountable for performing to the baselines set at CD-2; risk registers should be updated at CD-2 and utilized during the duration of the project, to mitigate any design changes required to successfully scale from TRL 6 to a full-scale operation.

Project-Specific Procedures

Some major projects have incorporated some of these tools into a project-specific procedure used to manage design maturity issues and perform associated self-assessments, to ensure sufficiency of design maturity. CMRR at LANL is one such project. Their procedure draws heavily from a PDRI-type model and delineates specific roles and responsibilities to generate a comprehensive review of design maturity, recorded to support future performance and risk register reviews, design reviews, and audits.

Design Maturity Issues/Considerations

Application of these tools, on their own, will not guarantee sufficiency of design maturity. All business units and projects require people, operations, and strategy to execute; the tools provide a strategy and operational assessment from which the people can be successful. To that end, this section outlines some focal points that will help project managers maximize the utility of the design maturity assessment tools and drive performance to the greatest possible extent.

Cost/Schedule Pressure and Considerations

Always present and always acknowledged, virtually all projects that are unsuccessful due to lack of sufficient design maturity will point to cost and schedule pressures as a primary cause. In the past, particularly illustrated over the last few years with the element of ARRA funding, some projects have fast-tracked design efforts to meet cost and schedule constraints, which results in very aggressive approaches, have historically had a higher failure and cancellation rate prior to CD-2 due to design maturity and quality issues.

The following issues should be considered with respect to cost and schedule pressure:

- **Rigor of TRL-6 determination at CD-2.** TRL levels can be subjective in nature, as with all models. Appropriate rigor must be applied to the TRL determination at CD-2, to ensure that it does really meet TRL-6, which is demonstrated performance on a pilot-scale. Changes to design due to design maturity issues beyond CD-2 will potentially affect the successful completion of the project, but is also the crux of the current focus on sufficiency of design maturity.

- **What is the appropriate TRL level at CD-1?** Guidance for TRL levels provide for technology development at TRL-3 and TRL-4 through technology demonstration at pilot scale at TRL-6. On complex designs, such as nuclear and chemical processing facilities, this becomes vitally important with respect to assessing design maturity. Typically, alternatives analysis is performed prior to CD-1, leading to a TRL-4 status of technologies upon selection. However, proceeding through CD-1 prior to attaining a TRL-6 status can fast-track development and design activities, which leads to higher project risk due to uncertainty in design maturity. Fast-tracking of these activities may be prudent, but should not be done due to cost and schedule pressures. The decision relating to TRL levels at CD-1 is important to document early in the project, and ensure that associated issues in the risk register are listed and kept up-to-date.

- **Quality and rigor of independent design reviews.** It is vitally important to have a rigorous and intensive final design review to ensure the sufficiency of the design maturity. Project reviews, by nature, are intended to find problems and issues, in order to help the project be successful. However, many times, cost and schedule pressure can create environments where critical looks at design are not performed, true experts are not utilized, and optimistic dispositions of technical issues and risks are made during design reviews.

Good independent design reviews are insurance against design maturity risks; complacency in design reviews will lead to design maturity risk on projects with high technical complexity.

- **Pre-conceived solutions.** One aspect of alternatives analysis that is rarely documented or discussed is the pre-determined technology/design. This has occurred on several of the ARRA-funded and other fast-tracked projects, when funding was schedule-driven. Favoring or forcing a technology, in order to meet cost and schedule pressures or attempting to aggressively, and sometimes artificially, drive project efficiencies can often lead to project risk and failure, based on sufficiency of design maturity. It is very important that technologies be developed within the TRA guidelines, and that rigor in the TRA and alternatives analysis and selection processes associated with CD-1 activities be high.

Risk Register

It is very important to ensure that the risk register contains a comprehensive and updated list of qualitative risks associated with design maturity. The farther along the design progresses, the qualitative risks become more defined, allowing for quantitative risk to be accounted for, ensuring successful performance. Use of the tools presented above will provide input data for the risk register, but the rigor with which the tools are applied, and the frequency of analysis of the risks, has a large impact on the assessment of design maturity at CD-2, and the minimization of project risk in the approved baseline. Recent project assessments have noted that risk registers are not updated frequently enough; maintaining and accurate risk register will help ensure that sufficiency of design maturity can be achieved at CD-2 and beyond.

Effective Communications

Sufficiency of design maturity requires the integration of many different technical and management personnel. To prepare a CD-1 and CD-2 package, input from design engineering and nuclear safety must be incorporated into the suite of project management documents that assure compliance with all project requirements, and ultimately guide the locking of the cost and schedule performance baseline upon approval of CD-2. Again, lessons learned and project reviews indicate that poor communications between these groups can lead to poor performance on projects. For design maturity issues on technically-complex projects, it is imperative for technology development efforts, as documented via the TRA/TMP processes and other tools, be clearly articulated and understood by the project team, in order to assure appropriate design maturity.