

# A strategic approach to improved EPU implementation

by Dan O'Loughlin

**R**ecent extended power uprate (EPU) projects at nuclear power plants have exceeded budgets and schedules, confirming the formidable challenge these projects present. The cost of a large EPU project poses essentially a billion-dollar question: Is it maintenance, or construction, or something different? It matters what we call it, because names influence how we think, organize, and act, thus affecting strategy. And the wrong strategy often translates into less-than-optimal implementation, and in extreme cases, failure.

An EPU project is optimally successful only if it is delivered (1) within the total envelope of nuclear and industrial safety, (2) at the lowest total cost of ownership, and (3) predictably and under control. Meeting these criteria with the tools, techniques, and singular mind-set of greenfield construction or operations and maintenance (O&M) is problematic and prone to failure. Construction protocols are not sensitive to the regulatory demands of working in an operating nuclear plant, and O&M protocols are overly restrictive and counterproductive when applied to the scale of an EPU effort. A different strategy is needed.

The table on the next page lists attributes that define construction and O&M environments. The darker-shaded blocks in the table apply to an EPU and indicate a unique set of challenges that may explain the difficulty some owners and contractors encounter in the delivery of EPU work.

Although a major EPU may look like any

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*Treating a reactor's extended power uprate as though it is either construction or maintenance runs the risk of delays and cost overruns.*

other heavy construction job to a contractor, or like any other maintenance effort to an outage manager, it's actually a mash-up of the worst of both worlds—like remodeling one's kitchen while preparing a holiday dinner. Consider these typical conditions: The tedium of physical security and as low as reasonably achievable (ALARA) practices is pervasive, adversely affecting worker productivity. Simply gaining access to equipment, a structural member, or a system component is often the most challenging aspect of a task. Equipment installation often requires the disassembly and reassembly of fabrications and manufactured products. Anchoring to existing concrete involves the setting of concrete expansion anchors instead of setting embeds before the concrete is placed. Translating engineering/design documents into work plans for craft workers also presents a significant work-management challenge.

Naysayers may argue that plants maintain procedures for modifications and that these can be applied to an EPU. But anyone who has implemented a large-scale EPU, particularly at the work-group level, will certainly confirm that such work is different.

Without an integrated strategy, the project is threatened by divergent tactical approaches favored by individual work-group leaders, depending on their experience and perspectives. On the other hand, a strategy that aligns organizational efforts could yield improvements of 30 percent or better over recent project durations.

One way to mitigate the risk of a large-scale EPU is to break it into segments for phased implementation over several out-

ages, thereby keeping the scope of each phase within the plant's organizational capability. Still, even reduced-scale EPU modifications are challenging, and the insights offered here may be applied to any scale of capital program.

## Scope, scale, resource demand

The scope, scale, and resource demands of an EPU or other major modification set these projects apart. An EPU project for a single unit may include 30 or more plant modifications, ranging from instrument rescaling to wholesale replacements of structures, systems, and components. Larger, higher-capacity equipment might have to be "shoe-horned" into existing structures, and the number of workers on site may be three to five times higher than during a standard outage.

Although a large project's infrastructure needs—such as access roads, parking, lay-down areas, temporary power, lighting, and utilities—are easy enough to recognize, organizational requirements are harder to discern.

For example, during a recent EPU outage that exceeded its planned schedule by about 50 percent, work-management protocols proved inadequate, even though the site had been satisfied with them for years. The work-management information and reporting system was not configured to effectively link engineering documentation to work orders. At the same time, requirements for additional work planning, generated during the implementation phase, were difficult to isolate and track.

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## ATTRIBUTES OF CONSTRUCTION AND O&M OPERATIONAL ENVIRONMENTS

	Attribute	Construction Project Environment	O&M Project Environment
1	Scope, scale, and resource demand	Typically up to 2000 or more craft workers. Extensive engineered material acquisition and purchase of large bulk quantities of building commodities. New structures, systems, and components define/redefine plant configuration.	Averaging 400–800 craft workers. Parts from approved bills of materials, commodities issued from plant stores. Minor or no changes to plant configurations. Tasks are repetitive, risks are largely known and mitigated. Infrequently performed task/test evolution (IPTE) process for infrequently performed work.
2	Culture and accountability	Developed from scratch. Difficult to affect. Implementation supervisors may have limited ownership if they are not involved in the process of planning the work.	Culture is groomed and improved during on-line operations and optimized over successive evolutions, yielding best actual performance, which can be embraced by an accountable supervisor. Seasoned workforce tends to be grounded in nuclear culture.
3	Regulatory sensitivity	Limited until turnover/startup. Risk transferred through contractual terms. Minimal regulatory impact on construction operations. Lockout/tagout enforced with lock-and-key hardware.	Licensing mandates restrict risk transfer. Operational assessment on 100 percent of work scope. Intrusive regulatory footprint. Plant impact effects are pervasive—chemical and hazardous material controls, hot-work permits, transient combustible permits, radiological controls, ALARA measures, and mitigation of plant system impairments—constraining work execution. Unlisted chemicals are screened for disallowed ingredients. Physical security and fatigue/fitness-for-duty measures affect work group efficiencies. Out-of-service/clearance order procedures implement lockout/tagout regulations.
4	Work management	Skill of the craft, working to plans and specifications. Limited craft/supervisor verification or place-keeping requirements. Limited specialty training. Earned value management systems form the basis of project control efforts. Weekly/monthly reporting.	Rule-based/procedure-driven. “Independent worker qualified” craft use work-order documentation with stringent verification and place-keeping sign-offs. Daily/by-shift reporting—hourly on critical path. Head count, daily earn-versus-burn rates, and finely granulated schedule activities form the basis of project control efforts.

Darker-shaded cells represent attributes of an EPU/major modification operational environment.

On the same project, an investigation of work delays revealed lost opportunities to simplify quality assurance measures on temporary structures. The plant’s standard assurance requirements for modifications were not reassessed for improved efficiency, even though the scope and nature of the temporary work might have been adequately addressed with measures that were less time-consuming. Furthermore, the application of standard work-order management protocols for out-of-service tags and plant-impact assessments resulted in redundant activities by over-tasked plant operators.

Additional examples of inefficiencies and organizational dysfunction from a recently completed EPU project include failed in-processing methods; widespread misunderstanding of procedural requirements, resulting in failed procedural applications and inconsistent interpretations; failed integration of engineering and work-order development; ineffective schedule protocols; inadequate training; and failed material acquisition protocols.

What is to be made of these shortcomings? Just as experts in the field of human performance speak of “organizational accidents” to deemphasize individual blame and to accentuate the causal chain of events that lead to serious accidents, we can speak of “organizational dysfunction” arising from the execution of incomplete or poorly

formed strategy. The most capable individuals cannot be successful on a major project without an effective organization supporting them, and effective organizations cannot be developed around strategies that are blind to the actual risks and challenges confronting the project.

A hidden connection is stronger than an obvious one. On large EPU projects, the hidden connection to nonoptimal results may be traced to systemic shortcomings within the project organization. These limit or prevent the effective collaboration of individuals and work groups to adapt to problems and execute solutions. Cooperative relationships must exist between contractor and owner engineering groups and among plant operations, maintenance, radiation protection, and other support groups. Planning must be integrated by the project and plant work-management groups.

Although everyone may agree to get along, systemic shortcomings can still develop because processes and procedures are applied without considering the operational environment. Adopting routines, processes,

and procedures without considering how work will be performed during the modification leads to organizational dysfunction.

### Culture and accountability

To get a flavor of the cultural differences between construction and plant O&M, compare these two expressions: “DTA”—don’t trust anybody!—which circulates

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among many construction workers, and “Trust permeates the organization,” item three in the Institute of Nuclear Power Operations’ (INPO) 2004 document, *Principles for a Strong Nuclear Safety Culture*. It’s a stark contrast.

An EPU project may employ hundreds of craft workers who are new to nuclear and are unfamiliar with the fundamentals of a nuclear safety culture. These workers typi-

cally bring a much higher risk tolerance to the job, well beyond what most plant O&M organizations are willing to accept.

*Accountability* is a term that is used extensively and is widely understood within the nuclear O&M world, but it is generally not found in the vocabulary of most construction sites. Accountable behaviors, which include openness, full disclosure, trust, and a questioning attitude, are challenging to nurture and grow and are mostly foreign to construction environments.

Two factors tend to hinder the development of a safety culture and accountability on a major nuclear modification project. The first is the historical separation of in-house organizations from contractor, project, or even corporate work groups on the work site. With few exceptions, a “we-they” atmosphere pervades the in-house organization, often getting in the way of productive collaboration within a project. The second is the relative success of maintenance and refueling outage execution and the belief that this success can carry over to major modifications.

First-line project supervision is the most significant victim when these factors are not addressed. INPO’s 09-007 document, *Principles for Excellence in Nuclear Project Construction*, lists strong first-line supervision as a key to project success and one of nine attributes of excellence in nuclear construction. The document also reemphasizes industry findings from the mid-1980s reported in the Nuclear Regulatory Commission’s NUREG-1055 that identify ineffective first-line supervision as one of the causes of substandard performance during nuclear plant construction in the 1970s and 1980s.

Even today, effective first-line supervision remains problematic. Early into a recently completed EPU, a senior manager announced the results of an assessment of productivity and effectiveness. The assessment revealed that contractors’ first-line supervision “didn’t have a clue” as to what their job accountabilities actually were—this on a site where fairly comprehensive oral boards were conducted with first-line supervisors, including general foremen and foremen. (An “oral board” is an oral examination conducted by a panel to determine whether an individual has attained a proper level of knowledge. It is an assessment process that many nuclear utilities have adopted to ensure competency among supplemental first-line supervision.)

Leaders direct, align, and give purpose to action. The most significant direction and alignment that senior leadership provides for an EPU project are strategies that bridge the cultural and accountability differences among individuals and groups within the project organization. Without organizational alignment, the owner’s and the contractor’s various operating, supporting, and staffing organizations will gravitate toward their own

cultural norms, whether or not those norms are optimally effective for the project.

The construction industry has introduced partnering concepts and practices that have effectively bridged organizational divides on multibillion-dollar civil and defense projects. These should be applied within the nuclear industry. An EPU or major modification project requires a contract that recognizes the differences between O&M and construction and provides project-specific protocols and provisions that are suitable for a modification environment. Under an engineer-procure-construct approach, the contract should align the owner’s capital project organization, the plant organization, and the contractor. Under a design-bid-build approach, multiple contracts require similar coordination.

### Regulatory sensitivity

Power reactors are highly regulated, even when a reactor is defueled, and the licensee maintains regulatory obligations for oversight. This reality, perhaps not always appreciated from a greenfield construction perspective, is reflected in item five of the INPO safety culture document, which reads: “Nuclear technology is recognized as special and unique.” Every aspect of the nuclear O&M environment, including procedures for plant modifications, has been fine-tuned to advance nuclear safety and ensure regulatory compliance. Each operating nuclear facility has its own library of procedures to address work in the plant. Under system-wide standards, there is often a second library of fleet requirements. But such fine-tuned methods seldom accommodate the demands of an EPU-scale capital program.

Without compensating measures, EPU projects confront rigid procedural constraints that may adversely affect project delivery without adding to safety, quality, or risk mitigation. Often, there are repetitive operational assessments of project work packages, application of lockout/tagout controls, and review of radiation protection permits. O&M protocols for physical security, plant access training and unescorted access authorization, fire protection, material control, work management, and quality assurance often add redundant administrative layers and constraints, as can programs for problem identification and resolution and corrective actions and assessments. At the same time, regulatory mandates require stringent configuration con-

trol measures to maintain fidelity to engineering design documents. Extensive, documented verification is expected to yield flawless reconciliation between the physical plant and the plant on paper at levels of detail exceeding most nonnuclear construction standards.

And so, in addition to bridging cultural and accountability differences, an optimally successful EPU strategy must integrate the operational practices that are customary to the plant’s daily routines with the project support requirements of a major modification. Most plant procedures, even those addressing modification activities, are not developed to support this kind of work. Procedures are not typically developed with much, if any, concern for process efficiency, even though efficiency is a fundamental requirement for an optimally successful EPU. Project leadership must find an avenue for reconciling plant practices with the best practices required for the project.

This can best be accomplished through a rigorous bottom-up and top-down assessment of the procedures and protocols used in the EPU modification’s design, implementation, and startup phases. Assessments are followed where necessary with specific procedural amendments, supplemental

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procedures, and alternative methods to align cross-organization efforts. Examples might include the following:

- Application of global assessments, tagouts, and radiation work permits.
- Work-package development that optimizes procedurally mandated administrative oversight measures.
- Realignment of responsibilities within or between plant or project work groups.
- Decontamination of a work zone rather than planning work under the strictures that accompany contaminated spaces.
- Development of *ad hoc* procedures and verification techniques when risk evaluations indicate that alternatives can be more effectively applied without degrading nuclear safety.

Again, naysayers may argue that such an assessment and any resultant project-specific procedural changes only reduce

margins or diminish quality levels. Therefore, senior project leadership must provide direction and ensure that appropriate change management plans accompany any procedural or process changes.

### Work management

A common sight on a construction job is a plan table built from two-by-fours and plywood. The foreman and crew gather around it to review blueprints, conduct pre-job briefings, and lay out work. Compare this to a nuclear maintenance job where the foreman and crew typically huddle over a thick three-ring binder containing work-package instructions and procedural steps. Maintenance workers use place-keeping techniques to document completed steps and to indicate the one in progress. These images illustrate another stark contrast between maintenance and construction—namely, the delivery of work plans and documentation to craft workers.

INPO AP-928, *Work Management Process Description*, identifies work management as a six-step effort to screen, scope, plan, schedule, prepare, and execute work in order to maximize station reliability, manage risk, maintain safe and event-free operations, and maximize efficiency and effectiveness. The document focuses mainly on maintenance, mentioning construction only in relation to scaffold construction, and it does not treat modification work differently. Nonetheless, modification tasks require a different approach to work management. A typical maintenance task (a) is performed to a procedure, (b) has been done before, and (c) is highly risk-mitigated. A typical modification task, on the other hand, is more likely to be (a) based on the skill of the craft workers, (b) performed by

the moment it is being done are those who are doing it—everyone else, rightfully so, is either preparing for upcoming tasks or assessing what has already been done. The role of work management is to align all the activities leading up to the work group's effort so that there is maximum likelihood that when the work is finished, it complies with the specifications and has been performed event-free within the allotted schedule window—no small task, given the modification environment.

A work-management strategy for an EPU should leverage available technology. For example, although 3-D digital scans may be costly, the added value this technology provides for detailed planning and for communicating detailed work plans guarantees a good return on investment. Other technologies that are not widely deployed on EPU projects but hold significant potential include simulation techniques; bar coding of items that have been removed or replaced, or using bar codes to mark specific demolition or reconnection points; portable digital media to reduce paper in the field and to simplify record keeping for craft workers; digital photography in work-package documentation; and press-to-talk or other mobile services to improve work-group communications.

Work management includes scheduling, material management, and configuration control. Item four in INPO 09-007 emphasizes the importance of schedule ownership to project excellence: "Schedules are realistic and understood." Principle five, "Construction of a nuclear power plant has special requirements," and principle seven, "The plant is built as designed," emphasize fidelity to configuration control and materials management.

Fostering schedule ownership in a modification environment is more difficult. Often, those who are held accountable for schedule compliance (namely, first-line supervisors) have not played an active role in developing schedule logic, loading resources, or setting activity durations in the schedule. No involvement results in no ownership, and without ownership, a schedule can hardly be called realistic. Nor is it

likely to be understood.

Therefore, a work management strategy in a modification environment needs to ensure schedule ownership throughout the project

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a workforce that may be predominantly new to nuclear, and (c) part of a one-off structure, system, or component, with residual uncertainty and latent risks.

And so, in one sense, every task (or scheduled activity) in an EPU or major modification project could be considered an infrequently performed task/test evolution (IPTE). Admittedly, this use of the IPTE terminology is unusual, but it highlights the challenge of work management within a modification environment. Consider that the only individuals actually focused on a task at

organization, down to the work-group foreman—again, this is no small task. Since few foremen, general foremen, or other supervisors are involved in schedule development, a separate process of translating schedule ownership to these individuals is essential. This requires effectively and efficiently communicating the basis of the estimate, the basis of the schedule, and details of the work plans to the various work groups. The process needs to be flexible enough to accommodate valid objections or improvements that are identified in reviews by the first-line supervisors and other work-group members.

Material acquisition management for a major modification requires a rigorous and broadly applied identification and control process that efficiently delivers piece-parts, tools, and consumables into the custody of the implementing work group at the appropriate time and with traceable documentation completely intact. In a modification environment, this is optimally met through an owner's materials-management program that is integrated with the plant's work-management and supply-chain processes. Even if contractual terms necessitate some degree of separation between owner and contractor procurement activity, the integration of materials management and work planning should be maintained to facilitate detailed material accountability and traceability. This can be achieved with appropriate information technology solutions linking contractor and owner systems.

"Building the plant as designed" requires fidelity to the engineering documentation. When emergent work or field conditions generate supplemental design documentation, it must be integrated into existing work plans even while the work is progressing. This creates unique demands on the work-management information system. Although nuclear utilities maintain computer-based work-management systems, integrated to



some extent with engineering and plant operations, these systems may not adequately accommodate the level of activity generated by a major EPU modification. It may be necessary to develop alternative reporting protocols or to use additional data fields to meet the information demands of the project. Typically, simple reconfiguration efforts or the development of a new report format can make significant improvements in these systems.

## The strategy

The implementation of nuclear plant modifications can be improved through a strategy that (1) recognizes the modification environment as unique—that is, as neither maintenance nor construction, and (2) provides an aligned project organization across all parties and stakeholders. To this end, four principles can be applied:

1. *Call a spade a spade*: Develop contract documents that embrace the uniqueness of plant modifications and position the signatory parties for collaboration and risk mitigation based on a lowest total cost calculus.
2. *Align from the top*: Modification contracts should promote collaboration, cooperation, and coordination among all the project stakeholders—plant in-house, owner-corporate, and contractors. Create a vital culture that supports accountability, safety, and event-free work.
3. *Align from the bottom*: Conduct rigorous, comprehensive assessments of the procedures, processes, and protocols that will be applied during the project design and implementation. As appropriate, develop *ad hoc* processes or variances for project effectiveness.
4. *Give primacy to work management*: It's seldom too early to start the integration of design development and implementation planning. Adapt technologies to improve planning and facilitate communication.

Senior project leadership can make a good start on an effective EPU strategy by studying the INPO documents referenced in this article and defining the specific organizational features, protocols, and behaviors that will make these principles a reality. These include, for example, defining what will be done by senior and department managers to earn trust throughout the organization, establishing how schedule ownership will be obtained and sustained, and specifying reporting parameters so that work-management tools can be configured and validated.

Through partnering techniques and project charter tools, project leadership should communicate the strategy to subordinate managers, supervisors, leads, and individual craft and technical workers. The right strategy enables the organization to deliver an optimally successful project—safe and event-free, on budget and on schedule, and under control. **■**