Department of Energy
Washington, DC 20585

November 22, 2017

MEMORANDUM FOR DISTRIBUTION

FROM: WILLIAM A. ECKROADE
             ACTING DIRECTOR
             OFFICE OF ENTERPRISE ASSESSMENTS

SUBJECT: *Office of Enterprise Assessments Study of Good Practices in Improving Disciplined Operations at Department of Energy Nuclear Facilities – November 2017*

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted a study to identify good practices that DOE organizations might consider when developing improvement actions to recover from events where nuclear-related operations deviated from established procedures, resulting in increased safety risks and potentially long term shutdowns of site mission related activities. Two recent major operational improvement efforts that engaged entire organizations in substantive change were selected to study. EA undertook this effort to understand how the selected organizations responded to operational concerns through deliberative change management to achieve sustained improvement.

For this study, EA reviewed the National Nuclear Security Administration Production Office's Y-12 National Security Complex and Pantex Plant, managed by Consolidated Nuclear Security, LLC; (CNS) and Savannah River Site activities managed by the DOE Savannah River Operations Office and Savannah River Nuclear Solutions, LLC (SRNS).

The results of the study brought to light a common theme of senior management involvement, with a focus on improving all areas of the organization and not focus on individual workers. The operational deviations analyzed by the CNS and SRNS organizations suggested that an *operational drift* – a gradual shift away from adherence to stated organizational standards – typically resulted from not faithfully implementing the work practices that embody the organizational standards developed to ensure safe and compliant work activities. The study identified the following four good practices for organizations pursuing improvement efforts to sustain disciplined operations:

➢ An improvement strategy and implementation plan are crafted based on senior management's strategic vision, using established and validated organizational improvement models, and communicated and championed by visible senior management ownership.

➢ Organizational and individual competencies are developed to observe and analyze operational performance as foundational for continuous improvement of the organization.

- ➤ Local Federal office(s) and the operating contractor act collectively in the improvement approach, recognizing that success depends on engagement of both entities while respecting their proper roles and functions.

- ➤ Enterprise-level processes are used to monitor for operational drift and address performance declines with a goal of preventing those declines from culminating in a significant event.

If you have any questions, comments, or feedback, please contact me at (202) 287-5403. Alternatively, your staff may contact Thomas Staker, Director, Office of Environment, Safety and Health Assessments at (301) 903-5392.

Attachment: *Office of Enterprise Assessments Study of Good Practices in Improving Disciplined Operations at Department of Energy Nuclear Facilities – November 2017*

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Office of Enterprise Assessments
Study of Good Practices in Improving Disciplined Operations at Department of Energy Nuclear Facilities

November 2017

Office of Environment, Safety and Health Assessments
Office of Enterprise Assessments
U.S. Department of Energy

Table of Contents

Acronyms

CAS   Contractor Assurance System
CEO   Chief Executive Officer
CMM   Capability Maturity Model
CNS   Consolidated Nuclear Security, LLC
DOE   U.S. Department of Energy
DOE-SR   DOE Savannah River Operations Office
E2   CNS Enterprise Excellence
EA   Office of Enterprise Assessments
EFCOG   Energy Facility Contractors Group
FY   Fiscal Year
HRO   High Reliability Organization
IAEA   International Atomic Energy Agency
IEB   SRNS Independent Evaluation Board
LAI   Lean Advancement Initiative
LSS   Lean Six Sigma
MFO   SRNS Management Field Observation
MIT   Massachusetts Institute of Technology
NNSA   National Nuclear Security Administration
NPO   NNSA Production Office
OLOI   Objectives and Lines of Inquiry
PBL   CNS Performance Based Leadership
SMRB   SRNS Senior Management Review Board
SRNS   Savannah River Nuclear Solutions, LLC
TQM   Total Quality Management
VTC   Video Teleconference
Y-12   Y-12 National Security Complex

**Office of Enterprise Assessments Study of Good Practices in Improving
Disciplined Operations at Department of Energy Nuclear Facilities**

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Environment, Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA), conducted a study to identify good practices that DOE organizations might consider when developing improvement actions to recover from operational deviations. EA noted that deviations in disciplined operations recur in organizations that had expended considerable resources to "fix" operational problems, usually focusing on the behavior of front line employees and featuring counseling, occasional employee firings, retraining, exhortations on strict procedure compliance, and procedure revisions. Yet, after a period of time, similar deviations recurred, sometimes in the same or other facilities where improvement programs were implemented.

The hazards and potential consequences associated with nuclear operations are such that workers must exercise the utmost rigor in the performance of work. This level of rigor is often referred to as *disciplined operations* – a broad term encompassing design, engineering, construction, maintenance, operations, and continuing verification by assessment of the facilities, equipment, and processes necessary to accomplish nuclear missions. The goal of disciplined operations is safety and effectiveness. As was emphasized by the study participants, disciplined operations require focused attention, a mastery of how work is to be done, and an understanding of why it must be done that way.

EA recently observed indications that a few DOE operations had undertaken operational improvement efforts that engaged the whole organization in substantive change. EA undertook this study to understand how two specific organizations responded to operational concerns through such organization-wide engagement. EA's goal in this study was to identify good practices that can be shared across the DOE complex in order to benefit other sites embarking on organizational improvements. In particular, EA sought to understand whether the changes at these sites engaged management and employee collaboration in ways that helped the organization work together to improve work practices and sustain performance.

For this study, EA reviewed the National Nuclear Security Administration Production Office's Y-12 National Security Complex and Pantex Plant, managed by Consolidated Nuclear Security, LLC (CNS); and Savannah River Site activities managed by the DOE Savannah River Operations Office and Savannah River Nuclear Solutions, LLC (SRNS). After discussions with EA, the senior DOE and contractor leaders responsible for CNS and SRNS missions agreed to support this study, and they subsequently devoted time and resources to help EA understand their ongoing improvement approaches.

The operational deviations analyzed by the CNS and SRNS organizations suggested that an *operational drift* – a gradual shift away from adherence to stated organizational standards – typically resulted from not faithfully implementing the work practices that embody the organizational standards developed to ensure safe and compliant work activities. In these nuclear operations, deficiencies in disciplined operations manifested as a series of operational events creating conditions inconsistent with the safety basis. Consistency in this area is important, because the safety basis provides the commitments and safety controls that DOE relies upon to approve the operating contractor to perform work with nuclear materials.

To understand the improvement actions initiated by the selected organizations, EA designed this study to explore the organizational changes under way, the basis for the changes, and whether management and workers see the changes as successful. An important aspect of the study was to understand the alignment between management and employees in the organization by examining what site personnel thought about change and their perceptions about organizational practices that influence how personnel work together, communicate, and establish priorities – specifically, whether the observed changes influence workers and work practices toward an overall sustainable improvement in performance.

EA found that the senior leadership of the study organizations were committed to substantive and sustainable process improvements in the organization, not just focusing on individual initiating events. The organizations' executives told EA that to achieve consistent discipline in performing work, leaders should not blame people, do low-value retraining, or impose increasingly detailed and restrictive procedures. Instead, they had to develop the systems and provide the resources necessary for qualified people to do good work.

This EA study identified the following four good practices for organizations pursuing improvement efforts to sustain disciplined operations:

➢ An improvement strategy and implementation plan are crafted based on senior management's strategic vision, using established and validated organizational improvement models, and communicated and championed by visible senior management ownership.

➢ Organizational and individual competencies are developed to observe and analyze operational performance as foundational for continuous improvement of the organization.

➢ Local Federal office(s) and the operating contractor act collectively in the improvement approach, recognizing that success depends on engagement of both entities while respecting their proper roles and functions.

➢ Enterprise-level processes are used to monitor for operational drift and address performance declines with a goal of preventing those declines from culminating in a significant event.

**Office of Enterprise Assessments Study of Good Practices in Improving
Disciplined Operations at Department of Energy Nuclear Facilities**

1.0   PURPOSE

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) performs assessments of complex activities and operations in order to provide constructive insights to support the safe performance of DOE's mission. In doing so, EA conducts special reviews and studies where warranted based on circumstances or performance, or as deemed important to mission sustainment. Through routine operational awareness activities, EA observed some distinctive performance improvement efforts at the Y-12 National Security Complex (Y-12), the Pantex Plant, and the Savannah River Site. These sites' improvement efforts were stimulated by prior operational concerns that warranted additional scrutiny by DOE and the responsible operating contractors. To better understand the changes under way, EA performed this study to determine whether the enhancements, both implemented and under development, represent good practices in organizational change and operational performance that could benefit other sites within the broader DOE complex.

2.0   SCOPE

EA identified disciplined operations as an FY2017 independent oversight target area in a memorandum to DOE senior line management dated May 3, 2016. This EA study evaluated the changes that selected sites implemented to address a series of operational concerns. The participants chosen for the study were the National Nuclear Security Administration (NNSA) Production Office (NPO), focusing on activities managed by Consolidated Nuclear Security, LLC (CNS) at both Y-12 and the Pantex Plant; and the Savannah River Site, focusing specifically on activities managed by Savannah River Nuclear Solutions (SRNS). EA discussed the scope of this study with the respective site managers before EA's scoping visits. The management of NPO and CNS agreed to collaborate with EA in designing the study approach and offered Y-12 and Pantex to be the first sites for the study. The DOE Savannah River Operations Office (DOE-SR) and SRNS agreed to participate as the third site in the study. The study was guided by objectives and lines of inquiry (OLOI) described in EA OLOI 31-01, *Disciplined Operations-Good Practices Study in Organizational Change*.

This study examined Federal office and operating contractor activities and processes associated with organizational improvements being implemented or developed. It was not intended to be a detailed analysis of all organizational changes, nor was it intended to evaluate the culmination of the improvement efforts.

3.0   BACKGROUND

Historically, although DOE organizations have sometimes expended considerable effort to resolve significant operational performance issues, improvement efforts have sometimes been difficult to sustain and operational events have recurred. In recent years, EA has detected indications that some organizations are taking unique actions as a result of operational events with a goal toward sustaining improved performance. Therefore, EA conducted a study to better understand these seemingly non-typical approaches, focusing on the following question:

How do organizations respond to, analyze, and resolve operational occurrences to preclude recurrence and develop the capability to minimize consequences from other events?

The descriptions of the site's experiences, how they came to understand their challenges, and the concepts they used to chart their way forward are summarized in this background section. In the two study cases (CNS and SRNS, with their corresponding DOE field elements), the leaders of these organizations told us their stories in terms of "this is what happened, here's how we thought about it, here's what we decided to do and why, and here's how we are going about changing things."

The report does not include much discussion of the technical details of the operational discipline occurrences that preceded the decisions to chart a new strategic direction. EA chose to limit such technical discussions because there was no single occurrence or specific event at either CNS or SRNS that mandated a strategic redirection. Several non-consequential safety-implicated deviations from expectations had occurred over a period of time, each of which was addressed in a "find and fix" manner.

The operational deviations analyzed by the CNS and SRNS organizations suggested that an operational drift typically resulted from not faithfully implementing the work practices that embody the organizational standards developed to ensure safe and compliant work activities. Operational drift (also called organizational drift or practical drift in the research literature) is the gradual, incremental, and essentially unnoticed decline in adherence to the organization's standards and expectations through the behaviors associated with the performance of work. It can occur, and usually does, at the front-line employee level up through and including the whole organization. No organization is immune to operational drift; the latent conditions that cause drift form slowly over an extended time frame and are very difficult to detect. These latent conditions form as an employee or organization starts taking risks by deviating from the normally accepted operational practices without experiencing detectable negative results. Personnel sometimes justify these risks by referring to the pressures of company profit, production goals, scheduling, budget constraints, and lack of resources. Individually, small deviations generally have little or no measurable effect on safety, so they are accepted as a new norm. Workers and the organization actually come to expect the new norm and see nothing wrong with the approach they are taking, especially if they are getting the job done without a negative event. In many instances, the innovations that lead to increased efficiencies and cost reduction are rewarded, but these are the very seeds of "deviation" that can interact in ways unknowable based on "local rationality." What looks like a good practice at the local work level may interact with other factors in the larger system to produce unforeseeable and unacceptable consequences in the future.

If left unchecked over time, operational drift may have a significant adverse impact on public and personnel safety, the environment, and/or mission accomplishment. The goal is to identify and arrest the drift before it becomes the new operating norm and becomes less visible. Although drift is often obvious in hindsight, it is difficult to identify in the moment as those closest to daily operations feel the daily challenges of balancing production goals with safety expectations. Management's engagement with workers and observation of ongoing work in the field are valuable sources of insight into operational drift because they may reveal behaviors inconsistent with the expected norms, as well as providing opportunities to reinforce behavioral expectations. Documenting and trending management's observations and coaching opportunities allow the organization to know whether behaviors in the aggregate are shifting away from organizational standards and to determine whether systemic remedial actions may be necessary for organizational change.

In CNS and SRNS nuclear operations, deficiencies in disciplined operations and the resulting operational drift manifested as a series of operational events creating conditions inconsistent with the safety basis. Consistency in this area is important, because the safety basis provides the commitments and safety controls that DOE relies upon to approve the operating contractor to perform work with nuclear materials.

When operational performance at a site starts to decline, the usual stated reason is a lack of discipline in the site's work practices. However, organizations often regard such improper practices as discrete events,

focusing on the deviation from expectations (or requirements) that closely preceded the event and directing corrective actions at individuals directly associated with the deviation. What is not always immediately evident is whether or how latent organizational conditions may have caused or contributed to the deviation. Therefore, the organization's corrective actions may focus only on the actions or inactions of individuals, not on latent conditions or cultural factors. If these conditions and factors remain unaddressed, the organization drifts away from adherence to its stated standards of operation – i.e., operational drift, also called normalization of deviance.

The site and organizational histories played a part in the organizational change efforts. For CNS, both Pantex and Y-12 had operated under separate contracts throughout their histories, each had strong and proud cultures, and the efforts to consolidate them under a new contract were, as admitted by both NPO and CNS, much more extensive and complicated than originally envisioned. In August 2014, NPO sent a letter to CNS outlining concerns about a series of operational discipline deviations that had occurred during the contract transition period and continuing after CNS had assumed management responsibility. Both NPO and CNS commented that the data they each examined about operational performance before and during the lengthy contract decision period indicated no apparent operational concerns. However, NPO's analysis of the occurrences suggested a need to go beyond "typical statistics" to identify whether there were "systemic problems and underlying causes." After considerable further analysis and internal, directed assessments, CNS leadership agreed that there were systemic problems and underlying causes, and determined that strategic intervention was necessary.

In April 2008, SRNS assumed the contractual responsibility for Savannah River Site environmental cleanup, operation of the Savannah River National Laboratory, and NNSA-related activities. The original contract was extended to 2016, and extended a second time to continue until July 2018. In early September 2015, SRNS identified that a procedure violation had occurred while moving special nuclear material, during a period when DOE and SRNS were evaluating apparent trends of other non-related operational concerns over recent months. SRNS officials and employees stated to EA that SRNS had a belief that their procedural adherence to nuclear activities with criticality implications was impeccable, and that this violation caused senior management to take prompt action. In combination with the other operational events, this violation called into question some fundamental management assumptions of the existing organizational culture – i.e., that procedural adherence and fidelity to the safety basis were an intrinsic value within SRNS.

The events that concerned senior management in DOE, CNS, and SRNS had initially been interpreted and acted upon as discrete occurrences to be fixed; however, on further reflection, these events were re-interpreted as signals that the organizations had tacitly allowed performance to deviate from defined expectations. DOE, and the operating contractor for each site (CNS and SRNS) all agreed that such tacit acceptance was unacceptable and must be remedied. Leaving aside the technical details, the essential message was about responding to organizational drift. Executives in the operating contractor organizations spoke with unusual candor about the deeply introspective discussions and deliberations within their management teams, using terms like "soul searching," and the technical issues, while of course important, were secondary to the human and organizational factors that were primary in the minds of the leadership teams as essential to change.

Accordingly, this report makes liberal use of terms from management and organizational sciences. The leaders of the organizations studied used language from management and organizational sciences to make it clear to EA that they were embarked on organizational change, not technical change. The management teams communicated that their focus was on nurturing an organizational culture in which performing work to expectations was the only accepted way to do work. Making this so was defined as the number one job of senior leadership. As one senior executive expressed it: "As an engineer I loved to design equipment and systems; but now my job is to design organizations."

One of the many notable distinctions in these organizations (both contractor and DOE) was that several members of the leadership teams had formal education and training in organizational sciences: some had graduate academic degrees, some had related professional certifications, and some had prior training and experience in organizational design and change in other complex domains, such as the U.S. Navy's nuclear operations. To support the improvement efforts in each contractor organization, leadership training was provided for all managers, from first line supervisors to the Chief Executive Officer (CEO), in order to institutionalize selected organizational science concepts and vocabulary as part of standard management practice. The CNS CEO personally instructed key modules of the Performance Enterprise System training, and the NPO Manager or Deputy Manager also provided a DOE endorsement and perspective at each course in that training. For SRNS, the Chief Operating Officer was the principal architect of the improvement strategy and was personally involved in leadership training and mentoring. As both a student and practitioner of organizational science, he explained the relevance of these concepts as using "a handful of mental models" to routinely reflect about his organization and to talk with his managers about improving the organization.

The literature on organizational change provides an important message: organization-level change is not fixed or linear. Extending this further, recent research on change management notes that the challenge of change is that a wide variety of approaches to change is available, and an equally wide range of situations in which these can be deployed. The issue for managers and others involved in organizational change is to ensure that the approach matches the circumstances. For the sites studied, a senior staff group with expertise in organizational effectiveness became the "bridge" to help translate the organizational change into tactics, and supported operations personnel as they analyzed and enacted improvements in their operating practices. These cases showed a systemic approach to improvement – for example, acknowledgment of operational drift, standardized work practices, understanding of mental models, culture, performance support tools, field observation, leadership development, operational excellence and continuous improvement, organizational learning, and sustainability.

Both CNS and SRNS chose learning-driven improvement strategies, based on a leadership philosophy that excellence cannot be forced but is an individual and collective choice facilitated by developing both individual and organizational acceptance and desire to continually self-assess and improve. Collectively, senior leadership across the federal and contractor organizations had success because they:

- Set the vision,
- Required integrity and mutual respect,
- Ensured that the management team was aligned on the mission and improvement approach,
- Made communication and education a top priority,
- Obtained necessary expertise in change and improvement methods,
- Initiated continuous improvement using small changes developed by management-authorized employee teams,
- Invested in technology-supported integrated management systems, and
- Subjected every aspect of the organization to forthright independent and self-assessment.

4.0   METHODOLOGY

To understand the improvement actions initiated by the selected organizations, EA designed this study to explore the organizational changes under way, the basis for the changes, and whether management and workers see the changes as successful. An important aspect of the study was to understand the alignment between management and employees in the organization by examining what site personnel thought about change and their perceptions about organizational practices that influence how personnel work together, communicate, and establish priorities – specifically, whether the observed changes influence workers and work practices toward an overall sustainable improvement in performance.

Each organization provided overviews of the change efforts and relevant history, and EA examined some of the reported activities in more detail than others, based on their significance as revealed by interviews, focus groups, or EA's consideration of innovative value or potential relevance to the broader DOE community. The study participants consisted of a sample of individuals and groups engaged in or affected by the ongoing change efforts. When the participants' responses to EA's lines of inquiry suggested possible misalignments between management and staff concerning implementation of the organizational changes, EA expanded the participant sample to elicit further clarification.

EA conducted a literature review focusing on organizational change in nuclear and similar high-hazard operations and developed a model of organizational change and factors for change management success by synthesizing concepts from the literature. With these as reference, and input from team members' experience, EA developed OLOI and documented them in EA OLOI 30-01, and also wrote interview questions to supplement the lines of inquiry and facilitate data collection. Standard social science methods of triangulation (cross verification through two or more sources) were employed, using document reviews, interviews, focus groups, and observations to acquire data. Also, EA encouraged participants in interviews and focus groups to express their opinions about practices they perceive as promising.

As themes emerged from iterative data analysis, EA considered the participants' perspectives as input for identifying promising practices that could eventually be designated as good practices or enablers for success. EA noted numerous promising practices across strategic and operational levels. Promising operational-level practices tend to be tailored to the mission, work, hazards, and culture; and promising practices at the strategic level are more likely to be applicable across DOE mission lines. Therefore, EA's identification of good practices focused on the strategic level; selected examples of operational practices that support implementing a good practice are expressed as enablers for success. Also, practices that can impede progress were identified as challenges/barriers to success. In summary, the three categories of practices identified are:

➢ Good practices: *Unique practices in support of an organizational strategy that offered reasonable assurance of sustainable performance improvement.*

➢ Enablers for success: *Organizational behaviors that supported the implementation of a systematic improvement strategy.*

➢ Challenges/barriers to success: *External or internal factors that could impede an organization's ability to fully implement its strategy as planned.*

EA considered a promising practice to be a good practice if it had one or more of the following characteristics:

➢ It was implemented at all sites selected for study.

> It was implemented at only one site but is consistent with the success factors identified during the study and described in Appendix C.

> It was implemented at only one site but is consistent with the principles and practices of high reliability organizations (HROs), as described in Appendix C.

> It demonstrates implementation of all objectives of EA OLOI 30-01, thus indicating a mature change program.

Appendix C discusses the methodology and methodological considerations in more detail.

5.0   RESULTS

5.1 Overview of Results

The groups EA examined – NPO and CNS at Y-12 and Pantex, and DOE-SR and SRNS at the Savannah River Site – differed in the specifics of their improvement actions, but they shared a common strategic approach. At all sites, senior management talked about the philosophies that gave shape to their strategy, as well as the set of ideas and questions they use to think about helping their organizations succeed. The change leaders in the selected organizations shared a common philosophy. They recognized that the senior managers need to understand the underlying organizational issues and that a lot of organizational problems are caused by the behaviors of the management team and how workers interact and react. Further, without continuing vigilance by management, eventually the system will create opportunities for the workers to fail. They also recognized that management needs to exhibit behaviors that lead to each workers success, and that the job of leaders is to craft the strategic direction and the future state of the organization.

The common approach to these cases can be characterized by:
- Using a systems approach that considers the entire enterprise of contractor operations, DOE direction and oversight, and external agents and influences, including budgets and strategic national interests that could impact mission direction;
- Embracing a culture of mutual respect, open communication, performance to expectations, and continuous improvement;
- Facilitating formation of mental models of what "good" looks like, shared among management and employees as appropriate to their work types and organizational responsibilities;
- Supporting continuous learning by individuals and the organization as integral to work performance;
- Standardizing work processes and practices whenever possible to enable consistent high performance with the assistance of tailored on-the-job training aids;
- Nurturing individual and organizational resilience to be aware of the unexpected, to enable conservative decision making when faced with uncertainty, and to foster innovation consistent with the rigor and prudence demanded of hazardous high-consequence missions and work tasks;
- All work is compliant with requirements and meets or exceeds expectations; and,
- Work commences only once is it is proven safe to the satisfaction of management, technical specialists, and work performers.

EA identified 33 practices that were promising and 14 practices that could be viewed as challenges/barriers to the site's ultimate success. EA further evaluated and screened the results according

to the characteristics described in Section 4.0 to arrive at four good practices, eight enablers to success, and six challenges/ barriers to success.

5.2 Good Practices

Each of the following good practices represent shared elements from both cases studied. Each good practice statement is accompanied by a "How it was described" discussion distilled from how the organizations described elements of their strategic approaches and the implementation of actions to align operating practices with the strategic intent. These descriptions were derived from focus groups and interviews that elicited examples of expectations and behaviors associated with implementation of the practice.

While CNS and SRNS had similar strategies for improvement, there were differences in the operational practices and tools they chose to implement the strategies. In large part, these differences were a function of two factors. First, CNS had only recently assumed operational responsibility for Pantex and Y-12 when operational concerns caused management to revise the change approach developed to accomplish contract goals. Second, since the contract focused on merging the two sites, CNS had proposed an enterprise change approach employing a suite of improvement approaches that had been validated in both commercial and defense applications. The reorientation placed priority on operational improvement and consistency as the focus by which the merger goals and contract efficiencies could be achieved and sustained.

SRNS had a history of over seven years of successful mission accomplishment. A number of strong performance analysis and enhancement programs were in place, with long pedigrees and broad acceptance within SRNS. These included project management, employee-led safety teams, human performance improvement, integrated procedure systems, and a recently implemented recovery process (dating from a pause in operations) that included enhancements to the contractor assurance system (CAS), management field observations (MFOs), senior management review boards (SMRBs), and an independent evaluation board (IEB). Also, in recent years SRNS had added the use of Lean Six Sigma improvement approaches (described further in Appendix C). SRNS's implementation approach was, in general, to pause operations as an intervention to align the entire organization on disciplined operations expectations, and to use MFOs, SMRBs, and the IEB for reflection on operating practices and for evaluating (and revising as necessary) procedures. The new approach was in effect a re-baselining effort. For sustainability, the organization developed and communicated the new approach through an Operational Excellence model. Leadership development, employee development, and robust contractor assurance, combined with the Operational Excellence model, became the central enablers for improvement.

> **Good Practice 1:** *An improvement strategy and implementation plan are crafted based on senior management's strategic vision, using established and validated organizational improvement models, and communicated and championed by visible senior management ownership.*

How it was described:

CNS called it "Performance Excellence" while; SRNS called it Operational Excellence. An SRNS president's message stated it as "Continuous improvement can evolve two ways: proactively or responsively. At Savannah River Nuclear Solutions, we strive for the former." The CNS CEO spoke of "giving every task our best effort, continuously improving the way we work and responding appropriately to issues." In both cases, organizations responsible for different types of operations and operating in different contexts recognized that their work practice was not always living up to their expressed expectations for performance. While some of the language SRNS and CNS used to describe the strategic approach was different, the central tenet for both was to pursue excellence and

prepare for the unexpected.

The SRNS and CNS senior management teams developed their corporate improvement strategies and implementation plans which were focused on self-evaluation, continuous improvement, and organizational learning. A cross-section of site personnel knowledgeable of site operations from various levels in each organization participated in developing the respective plans. The plans and associated communications were further refined to address a broad range of employee inputs and to clearly communicate leadership's expectations. For SRNS, it was the "Sustainment Plan to Improve Operational Performance," while for CNS it was the "Execution Plan for Establishing Excellence." Once developed, the entire management team at both SRNS and CNS aligned to translate their respective plans into operational terms tailored for their organizational sectors.

The improvement actions were elaborated through models that clearly represented each site's operational standards and management expectations. CNS called its model a "Strategic Framework for Achieving Performance Excellence," while SRNS entitled their model a "Path to Operational Excellence." Both organizations were careful to make the response actions of their respective models easy to understand and visible throughout the organization. Behaviors for self-improving performance were defined by organizational level: executive/senior manager, manager, supervisor, and individual contributors. Both organizations adopted conservative decision making approaches that emphasized prudent choices over allowable choices. The models serve as physical artifacts that reflect the belief structure of the respective organizations and have become a tangible foundation for each organization's culture moving forward.

Each organization adopted a change management process to assist the site in implementing the change. CNS chose to use a behavioral science based commercially available model for organizational change management. The CNS CEO and the executive in charge of the Performance Excellence support group were previously certified in that model having used that system in successful organizational mergers for the U.S. Navy. SRNS chose to use an internally developed project management approach to manage the change effort. The SRNS Senior Vice President, Environmental Management Operations holds a professional certification in project management from the Project Management Institute; the SRNS Executive Vice President and Chief Operating Officer earned a graduate degree in systems technology and had extensive prior experience in employing similar systems-focused management change efforts in previous nuclear operations; and the current SRNS operations have a long history of change programs using project management practices. A communication strategy was structured to embed the improvement efforts and standards in all aspects of employee engagement.

In both cases, the senior management team identified the following important failure/success factors:
- implementation of an improvement plan that specifies a one-way approach (i.e., flows down only) and assumes that employees will get on board is most likely destined for limited success in resolving the underlying causes of operational drift;
- delegating overall responsibility to lower management levels in the organization will most likely result in limited success; and,
- senior management must understand how the organization operates and be sensitive to the interests of managers, employees, and stakeholders whose self-interests may be affected by the change (organizational politics and culture).

Each organization defined an improvement approach to achieve excellence in performance through continuous improvement using Lean Six Sigma principles and similar proven improvement methods as the way to achieve mission and management efficiency goals. The approaches acknowledged that the organizations will never reach a final destination of performance excellence; instead, the

8

organizations recognized that it is a journey on which the organizations must continually improve and maintain diligence to be successful. In implementing these improvements, the organizations have to continue working as a team to implement changes and continuous improvements to enable consistent high levels of performance.

> **Good Practice 2:** *Organizational and individual competencies are developed to observe and analyze operational performance as foundational for continuous improvement of the organization.*

How it was described:

At both CNS and SRNS, the senior leadership evaluated individuals in leadership positions for competencies to drive the organization to higher levels of performance and maintain an environment of continuous improvement. Both CNS and SRNS crafted leadership development approaches using behavioral science research combined with applied practice to address knowledge and performance areas that needed improvement. Development efforts engaged the whole organization with managers and supervisors attending leadership classes, and training for individual contributors, to communicate management's expectations for conservative decision making, procedural adherence, continuous improvement, and meeting operational standards.

Both organizations developed and conducted seminar-style training to reinforce the alignment among site leadership and employees on the recovery actions. Leaders directly contributed to crafting and conducting the seminars to tangibly demonstrate their commitment, display ownership, and engage all employees in implementing the improvement actions consistently throughout the organization. The training was explicitly conceptualized as a means to shape shared mental models and shared language by which the expected norm is initiated and sustained. The communication strategy employed method(s) to ensure that each individual in the organization was introduced to the improvement actions in order to commence the journey toward a new organizational culture. Senior site leadership engaged directly with employees to communicate the operational standards and expectations. The leadership team was clear that the vision, along with the institutional culture and identity, was focused on long-term performance improvements and sustainability transcending the tenure of any one operating contractor.

In the case of SRNS, the sustainment plan emphasized that "greater intensity and depth of management engagement is required to train and coach our employees to achieve our expectations of performance." It further noted that "This plan is expected to be revised as the organization learns and adapts." Enhanced engagement was initially promoted though small group sessions held in every organizational unit during the operational pause. During subsequent deliberate operations, MFOs assumed a new prominence and were intended to be a mainstay of communication, coaching, and engagement. SRNS defines deliberate operations as follows: A timeframe where processes being conducted require specific, intentional, and well-thought-out actions in the identification of critical activities. During this period, only work approved by the Facility Manager may be performed. All work is expected to be performed in a slow, very deliberate manner with more attention given to the critical steps. Management engagement in the field was also greater. Supervisor development programs for first line managers became mandatory across the organization. The Chief Operating Officer and other SRNS senior management personally taught modules to share and stress that leadership values and philosophies are to be communicated to the most junior levels of management.

SRNS used small group meetings to facilitate communication of expectations and establish alignment through the organization. All levels of leadership conducted small-group meetings to engage employees in a more intimate setting and allow for candid discussion and improved acceptance. The small-group sessions included demonstration of employees' understanding of the organizational

standards through scenario-based training. Small group meetings were used to discuss compliance with operating procedures and identify where the employees might have difficulties in compliance because of the accuracy or quality of procedures, or poor working conditions. Performance support tools were developed and applied to facilitate continuous monitoring and analysis.

SRNS also instituted the practice of short term operational pauses (e.g., several hours of a shift) to provide an opportunity for in-depth discussion of some aspect of a production job so employees gain better mission mastery and understand the basis for safety controls. Understanding the operational interdependencies of the overall operational processes and the "Why?" was foundational to individual commitment to rigor of operations.

- ➢ **Good Practice 3:** *Local Federal office(s) and the operating contractor act collectively in the improvement approach, recognizing that success depends on engagement of both entities while respecting their proper roles and functions.*

   How it was described:

   For both CNS and SRNS, the Federal field element and the operating contractor individually and collectively managed organizational change efforts to improve operational discipline. The executive leadership teams of both organizations shared mutual respect and were committed to move toward the new strategic vision in a coordinated fashion. The Federal and operating contractor organizations collaborated in shaping the strategic vision of where the sites needed to go. The operating contractor and the Federal field elements conducted routine partnership meetings to promote alignment of their performance standards and expectations. Efforts to improve, as well as observations and challenges to achieving those improvements, were openly shared. The partnerships were transparent, and all levels of the organizations engaged in mutual efforts. Senior management from each organization issued cosigned communiqués and demonstrated in words and actions the mutual efforts toward performance improvements. Federal oversight processes were tailored to maintain awareness of the improvement efforts and provide the appropriate feedback. Where appropriate, Federal and operating contractor organizations used the similar performance measurement tools, techniques, monitoring, and training, and both organizations used the same performance models and language to communicate the vision of excellence.

   For example, NPO designed a tailored oversight approach to monitor and provide value-added feedback to CNS on the design and implementation of Performance Excellence. DOE-SR did likewise for the SRNS Operational Excellence intervention. Executives of each DOE site element focused on selected elements as early indicators of potential drift. One senior Federal executive explained that conduct of operations, organizational culture, and senior leadership actions were key focus areas for such insights, and NPO developed a category of Emerging Items of Interest to focus attention on possible drift indicators. DOE-SR was in the process of shifting office locations for Facility Representatives and some subject matter experts to be based in the facilities for which they are responsible; the goal was to enhance their real-time operational awareness.

   Both NPO and DOE-SR changed their oversight approach and supporting activities and processes. NPO revised its oversight approach, as described in NPO Operating Philosophies and Management System Description, to define the roles, expectations, and methods for conducting risk-informed, performance-based oversight. Both NPO and DOE-SR emphasized a systems approach for oversight. For example, NPO now conducts integrated assessments of key activities to examine the interactions of business management and operational systems to support effective work performance, and DOE-SR monitors the activities and functions of the corporate board that oversees contractor management. Both NPO and DOE-SR increased the frequency of formal and informal communications with weekly

10

counterpart discussions, monthly information exchanges, and quarterly or triannual formal performance reviews.

➢ **Good Practice 4:** *Enterprise-level processes are used to monitor for operational drift and address performance declines with a goal of preventing those declines from culminating in a significant event.*

How it was described:

The highest level of leadership at both CNS and SRNS set the expectation that maintaining current operational awareness and discerning weak signals of operational drift must be foundational competencies of all members of management. Leaders committed themselves to be constantly vigilant for declines in operational performance. The organization developed multiple methods to monitor unexpected circumstances, conditions not anticipated in work plans, deviations from work plans or expectations, safety events, near misses, or opportunities for innovation or improving existing processes or practices. Daily, managers were on the lookout for "Good Catches" that prevented the performance of work inconsistent with expectations or resulted in opportunities for innovation. Senior management formally acknowledged individuals who identify such observations.

The organizations instituted formal processes to continuously monitor and analyze performance and identify both positive and negative operational trends. Multiple types of analyses were employed, including routinely tracked performance indicators tailored to each organizational level and work type; self- and independent assessments; and intuitive analysis that draws on the expertise of management and employees to answer the question "What might this mean?" to provide context, encourage real-time operational awareness, and reinforce shared mental models of "what 'acceptable' looks like." Also, methods were instituted to allow for the rollup of operational information leading to an overall organizational assessment of performance. Such assessments are intended to be attuned to subtle indications of an organization's performance that could indicate the beginning of operational drift.

CNS Performance Excellence utilized Lean Six Sigma (LSS) and Total Quality Management (TQM) methodologies to identify, evaluate, define, and implement process improvement. From a strategic perspective; it was designed to function as one CNS system and one CNS voice with all employees at the center of the model engaged in continual improvement of their work in collaboration with leadership and supported by LSS experts. Through the engagement of employees and with the use of expert LSS facilitators as well as LSS tools and workshops, CNS seeks to identify cost reduction and efficiency improvement opportunities, as well as facilitate integration of plant-specific processes into single enterprise-level processes. CNS projects also included Value Stream Mapping, Kaizens, Rapid Improvement Activities, and business cases to drive improvements and integration across CNS.

SNRS commissioned external reviews of its CAS. One of the innovations was to introduce Intuitive Analysis as an enhancement to traditional quantitative metrics and assessment reports. Intuitive Analysis draws on the tacit expertise of the organization to examine potential implications of data collected through the assessment information channels. The combination of qualitative intuitive approaches with traditional measurement approaches has enhanced the robustness of analysis and the quality of decision making in commercial nuclear power, in defense and in the intelligence community. SRNS adopted the lessons learned from the Energy Facility Contractors Group (EFCOG) CAS working group's guidance and focused senior management attention on the quality and frequency of MFOs. Daily, senior managers review operating experience reports and respond personally to Good Catches, not only to acknowledge employees for the specific catch, but also to recognize them as positive examples of desired performance.

Both organizations implemented processes to initiate a systematic and measured organizational response to performance declines prior to the occurrence of any significant events. Upon the recognition that an event requiring organizational response has occurred or that assessment of a number of events indicates that the organization is experiencing symptoms of operational drift, remedial actions are required to be developed and implemented. The intent was to make a strong response to weak signals and to focus the attention of the organization to arrest the forces of decline early. Potential remedial actions included several possible operational mitigative options ranging from heightened management oversight, to a series of short operational pauses (e.g., four hours each week), to a full operational pause. In addition, a plan for sustaining performance was implemented. This plan was designed to ensure that the "expected norm" is codified in site processes and procedures and that the appropriate levels of management monitoring, coaching, and oversight are in place to ensure organizational alignment.

5.3 Enablers for Success

Enablers were important to the overall success of the improvement initiatives. The enablers that had more influence on the success of an improvement process and normally touched larger portions of the organization are identified here as Global Enablers. Enablers that made a more limited contribution to improvement efforts are called Specific Enablers. EA views the two Global Enablers listed below as fundamental to the implementation of the studied improvement efforts and indispensable for long-term success and sustainment. The Specific Enablers are practices observed during the study that EA judged to have a lesser, but substantive, influence on the success of the improvement efforts. Specific Enablers were generally straightforward and routinely implemented within the organizations, and thus need no explanation beyond the statements provided here.

Global Enablers

➢ *The organization developed and implemented a communication plan.*

Communicating is essential to the success of organizational improvement. The communication plans for the chosen organizations described a broad view of how to provide the message of the organizations' vision and implementation actions (and the reasons for them) to all employees. They contained an integrated approach using audio and visual media, personal contact by senior leadership, the human resources and training organizations, all-hands meetings, small-group meetings, and other innovative ways the management team could reach out to employees.

The communication plans involved the entire management team. First and foremost, the plan had to have total buy-in from the management team, and each leader in the organization needed to understand how to implement it. The communication plans strived to create awareness within the organization of what the issues are and how they are to be addressed. They were designed to generate a desire on the part of employees to engage and participate in the change. A messaging strategy founded on awareness of the site's operating standards and the intended results was included in all aspects of daily operations. Embedded in the messaging was a clear understanding of "what is expected of me" and "what's in it for me." The rollout came from the most senior leaders in the organization, with follow-up reinforcement by all levels of middle management. Understanding how the message is being received was critical. For example:

- Do employees understand what is happening, why, and what is expected of them?
- Have employees bought into the changes, and are they engaged and participating?
- Are there unanticipated barriers that are undermining the message or impacting results?

All available forms of site communication were used to saturate the work environment with discussions of the improvement initiatives, new operating standards, and successes in site improvements.

➢ *The organization developed and implemented a sustainability plan.*

The sustainability plans were a disciplined approach to ensure that actions were in place to incorporate the organization's transformation into the culture, processes, procedures, and training of the organization. It was a deliberate list of actions and measures, overseen by management, which codified improvement efforts and provided objective evidence that the improvements were providing positive results. Plans for sustaining performance improvements were implemented before the organizations transitioned to the expected norm for operations. In addition, the plans ensured that appropriate levels of monitoring and oversight were in place. The plans included continuous efforts to ensure that the change was understood by every aspect of the organization, helping to give the expected norm a lasting place in the organization's culture. Senior management demonstrated continued support by assigning an executive champion and monitoring the implementation status of the sustainability plans.

Specific Enablers

➢ *Organizations implemented an effective management field observation process that results in increased management presence in the field and engagement with employees. The focus of management's increased time in the field is to have one-on-one or small-group meetings with employees to recognize good catches by the workers, verify the adequacy of work practices, reinforce conservative decision making and operating standards, and evaluate operational drift.*

➢ *Management looked for early success in improvement efforts, and communicated the details of the early successes to all employees and the Federal field element. They maintained a focus on understanding the factors of success instead of focusing only on failures as an approach to promote organizational and individual improvement.*

➢ *Organizations established periodic production pauses to allow workers to understand the big picture of how their jobs contribute to facility production goals. The pauses allow employees to understand their suppliers' and customers' needs and how the whole process integrates to support mission success.*

➢ *Organizations prepared a graphical representation of improvement initiatives so that site personnel could better understand implementation efforts.*

➢ *The management team ensured that metrics were established in the contractor assurance system that provide meaningful insights into the organizational improvements.*

➢ *Organizations implemented forums chaired by senior management to give first-line managers and facility supervision a conduit to provide unfiltered feedback that identifies the challenges they encounter. Field leaders needed to know that management heard and acted upon field concerns.*

5.4 Challenges/Barriers to Success

Challenges/barriers to success are external or internal factors that could impede an organization's ability to fully implement its strategy as planned. EA identified these challenges and barriers to success from the literature review as well as study participants' perspectives and perceptions gleaned from interviews,

focus groups, and observations. EA presents these challenges and barriers as lessons learned for other organizations consideration; not to imply that any of these directly impeded the overall success of the organizations in this study. Some aspects of change that can be critical to success are equally challenges or barriers if they are absent or poorly implemented as part of the improvement process. What is critical is that many organizations take these items for granted, resulting in limited success or in performance improvements that are not sustained.

➢ *Too much change too fast. A site going through significant change can generate confusion among employees as to what are the changes and what is their purpose.*

➢ *Initiating performance improvement activities at the same time as budget and personnel reductions. Staff attrition and recruitment practices can affect knowledge retention.*

➢ *Inconsistently implementing improvement efforts across the organization.*

➢ *Management personnel not setting aside sufficient time or resources to mentor personnel about the improvement initiatives and recent successes.*

➢ *Personnel not having a connection with the expectations of the senior management team.*

➢ *Defining improvement actions based on broad generalizations from commercial industry or military experience without rigorous analysis of their feasibility and implementation ability within DOE.*

6.0 Contact Information for the Organizations Participating in the Study

For additional information on the implementation and sustainability of improvement actions studied, please contact the following:

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Appendix A
Supplemental Information

Dates of Study

Onsite Study: Y-12 and Pantex: November 28 – December 8, 2016
Savannah River Site: February 20 – March 2, 2017

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EA Study Members for Disciplined Operations Study

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Edward Greenman	Edward Greenman
Frank Inzirillo	Barbara Guenveur
Joseph Lischinsky	Frank Inzirillo
Greg Schoenebeck	Nancy Kane
Mario Vigliani	Kimberly Leffew, CNS Pantex
Kevin Witt	Kevin Witt

Appendix B
Key Documents Reviewed, Interviews, and Observations

Documents Reviewed
- Consolidated Nuclear Security, LLC (CNS) Plan, CNS-F-0001, *Strategic Framework for Achieving Performance Excellence*, Revision 0, 05/06
- CNS Briefing, *Learning Organization Improvements*
- CNS Briefing, *CNS Leadership Training*
- CNS Mission Success Model Poster
- SRNS Memorandum *SRNS Plan to Improve Operational Performance,* Revision 1, 07/18/16
- SRNS Presentation, *Operational Improvements Update*, 1/31/17
- SRNS PLAN SRNS-N00000-2015-00053, SRNS Recovery Plan, 2015
- Henry Mintzberg, Harvard Business Review, *Crafting Strategy*, 07/87
- Sidney Dekker and Shawn Pruchnickic, *Drifting Into Failure: Theorizing The Dynamics Of Disaster Incubation*, 2014
- Government Accountability Office GAO/PEMD-91-10.1.9, *Case Study Evaluations*
- *Bryant University,* Published in 21st Century Management Editor: Dr. Charles Wankel, *Why Catastrophic Organizational Failures Happen Michael A. Roberto*, 12-2008, 2007
- Devorah E. Klein, David D. Woods, Gary Klein, and Shawna J. Perry, *Can We Trust Best Practices? Six Cognitive Challenges of Evidence-Based Approaches*, 2016
- Markus Baer, Kurt T. Dirks, and Jackson A. Nickerson, Olin Business School, Washington University in St. Louis, St. Louis, Missouri, U.S.A., *Micro foundations Of Strategic Problem Formulation*, 2012
- Michael A. Roberto, by Pearson Education, Inc., Wharton School Publishing, *Know What You Don't Know: How Great Leaders Prevent Problems Before They Happen,* 2009
- Bernard Burnes, Manchester School of Management, UMIST, Manchester, UK Management Decision 34(10):11-18, *No Such Thing As …a "One Best Way" to Manage Organizational Change*, December 1996
- Daniel Metlay, The BRIDGE. National Academy Of Engineering, *How Social Science Informs Engineering Practice*, Fall 2012
- Dr. Thomas P. Galvin1, Ed.D. and LtCol Lance D. Clark, USAF*,* United States Army War College Department of Command, Leadership, and Management Carlisle Barracks, Carlisle, PA Last Revision, *Beyond Kotter's Leading Change: A Broad Perspective on Organizational Change for Senior U.S. Military Leaders,* 07/16/15
- Jackson A. Nickerson, Markus Baer, Kurt T. Dirks from "Opening Up Innovation: Strategy, Organization and Technology" At Imperial College London Business School *Designing A Dynamic Capability For Strategic Problem Formulation*, 06/16 – 18/2010
- A Case Study, Daniel Johnstone Jirnal Vivek Peeraji, Lund University School of Economics and Management Department of Business Administration, *Quality Improvements and Change Management in The British Nuclear Industry*, 2014
- International Atomic Energy Agency (IAEA) Nuclear Energy Series No. Ng-T-1.1, International Atomic Energy Agency, Vienna, *Managing Organizational Change In Nuclear Organizations*, 2014
- IAEA-TECDOC-1491, *Management of Continual Improvement For Facilities And Activities: A Structured Approach*, 04/06
- Institute of Nuclear Power Operations INPO 12-011, *An Implementation Framework to Significantly Improve Nuclear Plant Performance Recovery Guidance for Corporate and Station Leaders*, 10/12
- NEA No. 5349 OECD, *Managing and Regulating Organizational Change in Nuclear Installations, CSNI Technical Opinion Papers No. 5,* Nuclear Energy Agency (NEA) Organization For Economic Co-Operation and Development (OECD), 2004

- Nuclear Industry Safety Directors Forum by the Nuclear Safety Capability Working Group, Second Edition, *Nuclear Baseline and the Management of Organizational Change: A Nuclear Industry Code of Practice*, 03/14
- Edited by William H. Starbuck And Moshe Farjoun, *Organization At The Limit Lessons From the Columbia Disaster*, 2005
- Harvard Business Review, Chris Argyris, *Teaching Smart People How To Learn*, 1991
- Bryant University, A. Roberto, *Why Catastrophic Organizational Failures Happen Michael*, 2008
- Beebe, James. *Rapid Qualitative Inquiry, A Field Guide to Team-Based Assessment*, Rowman & Littlefield Publishers, Kindle Edition, 2014
- See Jarzabkowski, P., J. Balogun & D. Seidl. 2007. "Strategizing: The challenges of a practice perspective," *Human Relations*, 2007, 60.1:5-27
- "User-Friendly Handbook for Mixed Method Evaluations," National Science Foundation, August 1997

Interviews and Focus Groups
- Y-12 NNSA Production Office Interviews (6)
- Y-12 NNSA Production Office Focus Groups (3)
- DOE Savannah River Office Interviews (5)
- DOE Savannah River Office Focus Groups (8)
- CNS Management Interviews (12)
- SRNS Management Interviews (15)
- CNS Focus Groups Employee and First Line Supervisors (26)
- SRNS Focus Groups Employee and First Line Supervisors (22)

Observations
- NNSA Production Office Pantex and Y-12 Daily VTC Interface Meeting
- NNSA Production Office Pantex and Y-12 Weekly VTC Interface Meeting
- NNSA Production Office/CNS Monthly Performance Review Meeting
- CNS Performance Excellence Training Class
- SRNS Transition to Leadership Training Class
- SRNS Safety Management Review Board
- SRNS Operational Excellence Review Board
- SRNS Presidents Safety Council
- SRNS Local Safety Improvement Team Forum
- SRNS Facility Safety Improvement Team
- SRNS Monthly Defense Nuclear Facilities Safety Board Meeting
- SRNS Subcontractor Safety Meeting
- SRNS Internal Monthly Business Review

Appendix C
Study Methodology and Conceptual Bases

The purpose of this study was to examine how organizations reacted to operational occurrences and what they did in response to those occurrences, and to consider the implications for sustaining safe, effective operations. The goal was to identify good practices that could benefit other DOE operations embarking on organizational improvements.

A typical EA assessment looks for deviations from the expectations set out in regulations, consensus standards, contractual agreements, and the like. In contrast, a study is descriptive: it seeks to describe what was observed. An assessment applies a frame of reference derived from standards, requirements, or good practices to evaluate the topic of inquiry. In a study, frames of reference may be useful to make sense of the emerging observations.

A Practice Focus

The study's frame of reference is practice-based, derived from empirical studies of what successful organizations do. Since the focus organizations in the study are complex and involve safety-significant technologies, the particular practice view is grounded in the concepts of high performing, resilient organizations. In a study to understand organizational change management, EA considered a practice-focused view of organizational strategy to be appropriate.

From a strategy-as-practice perspective, strategy is a socially-accomplished flow of activity that has consequential outcomes for the direction and/or survival of the group, organization, or industry. Strategic thinking is both analytical and creative; it involves gathering information from difference sources (including the technical, political, and social systems in which an organization exists, and the perspectives of many in the organization), reflecting on the values and strengths of the organization, and then synthesizing that learning into a vision for the direction of the organization.

The objective of analyzing an organization's strategic thinking is to discover and explain some aspect of activity that is consequential at the chosen level of analysis. It is about discovering the processes of formulating, negotiating, and enacting change. (See Jarzabkowski, P., J. Balogun & D. Seidl. 2007. "Strategizing: The challenges of a practice perspective," *Human Relations*, 2007, 60.1: 5-27.)

Organizational Science Basis for the Study

EA conducted a broad literature scan before finalizing the scope and approach of this study. The literature review examined various ways organizational change has been attempted and studied, with particular attention to complex, high-hazard organizations performing missions critical to the organizations' survival and progress, such as nuclear energy, nuclear defense, and similar high reliability demanding organizations. The literature scan included over 500 documents from which approximately 60 documents were selected as principal references for detailed review. Results of the literature review helped EA reflect on the data discovered during the study and consider whether the experiences of the chosen organizations might have corollaries in the published literature on change management in complex, safety-significant organizations.

From the literature review, EA developed an organizational change cycle management model (Figure 1) and identified key factors of organizational change. These were used as a comparative reference to provide a certain confidence level that the promising practices noted during the study have a pedigree in prior practice and are grounded in organizational and behavioral science. As the study progressed, EA focused on identifying topical areas or innovations not anticipated in the preparatory literature review,

and additional literature scans were conducted. Two examples illustrate this iterative research. In the CNS change effort, CNS placed an emphasis on "Lean Six Sigma" improvement approaches, and in the second site studied, SRNS's attention was drawn to adopting Intuitive Analysis to enhance self-assessment and contractor assurance. Both approaches prompted EA to review research particularly on the history of and current developments in the MIT Lean Advancement Initiative and Positive Organizational Development, and the Intuitive Analysis in military and intelligence operations, social science analysis, and the related concept of Cognitive Analysis in commercial nuclear power.

Background on Lean and Positive Organization Development

Lean is a continuous improvement management approach derived from the Toyota production system. The basic principles and concepts of Lean were articulated over two decades of research at MIT and adopted broadly to improve production in industry and the military. The MIT Lean Advancement Initiative (LAI) was a research consortium that was founded in 1993 and active through 2012. LAI's purpose was to enable enterprises to effectively, efficiently, and reliably create value in complex and rapidly changing environments. Over the course of nearly two decades, LAI's collaborative partnerships with industry, government, and academic partners fostered the development of institutional principles, processes, behaviors, and tools for enterprise excellence.

Positive Organizational Development focuses on understanding and developing organizational and individual strengths associated with excellence, such as values, purpose, meaning, and resilience that motivate and guide performance to exceptionally high levels. The approach gained attention in the early 1990s with research at the University of Michigan Center for Organizational Psychology and research on Appreciative Inquiry at Case Western University examining organizational change through the relationships of strengths, possibilities, and successes.

Using published literature for reflection is consistent with standard social science practice and seemed particularly relevant for this study. EA observed that similar scientific literature awareness was a valued component of the case organizations' change approaches. From document reviews, interviews, and focus groups, it was evident that a number of senior managers in the study participant organizations had a high degree of familiarity with and some pockets of deep knowledge about research and applied practice on high reliability organizations (HROs). For example, the CNS Strategic Framework for Achieving Performance Excellence notes that "CNS has adopted a framework for achieving performance excellence which is based on Senge's Five Disciplines Model (note – Learning Organization). The model provides a lexicon of terms and concepts that can be tailored to the various functional areas and activities within the operations areas." Similarly, SRNS senior managers displayed significant knowledge of and experience in organizational systems thinking, referencing research from MIT and Stanford. Notably, the causal analyses applied to operational occurrences related to the organizational change efforts and the improvement strategy were grounded in the concept of organizational drift. Senior management directed that the operational awareness aspects of the CAS should be enhanced to add Intuitive Analysis to the portfolio of quantitative metrics and formal assessments in order to build shared mental models, with a focus on operations and methods to maintain more real-time awareness of potential drift from expectations and requirements.

Data Collection

As previously discussed, EA developed a generic reference model (Figure 1) of organizational change, and identified factors for success in organizational change. Questions were designed to support inquiry about elements of the organizational change model. A team guide was prepared that discussed themes and concepts of organizational change as informed by the literature review, and a team orientation was

conducted to ground team members in common concepts, terminology, and research approaches. EA also developed a study plan as the basis for communication about and conduct of the study.

For data collection and analysis, standard social science methods of triangulation were employed: document reviews, interviews, focus groups, and observations of training and relevant meetings. Of particular help in preparation, the participant organizations provided a series of presentations and informal discussions on the main topics of the history and implementation of organizational change efforts. EA made no attempt to validate the accuracy of representations made or the perceptions shared during these data collection activities. EA was sensitive to maintaining anonymity; individuals were not identified in the team notes, and efforts were made to remove any references from material shared by individuals from participating study organizations.

EA designed the study to facilitate a systemic overview by using a three-part iterative inquiry as discussed in relevant systems analysis literature. A systemic approach addresses risks by examining how the complex interactions between human, technical, and organizational factors produce safety and performance on a day-to-day basis. Specifically, three overarching questions were embedded in the study design: "What does good look like?", "How are you doing?", and "How do you know?" The intent was to seek insights about mental models, operational awareness, and performance monitoring, as well as alignment on these factors within the organization. Operationally, the question set often proceeded along the lines of: "*What* are you doing?", "*How* are you doing it?", "*Why* are you doing it?", "*How* are you measuring how things are going?", and "*How* is it working?"

EA designed the inquiry protocols to invite the opinions, perceptions, and evaluations of those involved; EA's focus was to understand, not to judge the perceptions shared. The aspirational outcomes established for the study were to develop insights on how the change management strategy was proceeding and to determine whether the practices of change management and performance improvement observed during the study represent innovations and/or good practices of such merit as to be shared broadly within the DOE complex.

Learning History Informed Design and Analysis

The value of change efforts must be assessed, but traditional quantitative outcome measurements may be inhibitors to learning and change, and such measures may be oblivious to the relational and organizational factors that enable change and learning to occur. The learning history was developed as a new method of measurement to help an organization listen to what 'it is trying to tell itself' about its own learning and change efforts. Learning histories are not static reports for statistical analysis, rather they are intended to be used as the basis for group discussions by those involved in the changes and those who might learn from it. Learning histories are 'jointly-told tales' to build trust, raise issues that people want to talk about, but have not had the courage to speak out loud, for transferring knowledge from one part of an organization to another, and for crafting shared mental models and common language necessary to shape future organizational realities." (See "Field Manual for the Learning Historian Chapter One: Introduction to Learning History Theory and Practice - What is a Learning History" and "Learning Histories: Assessing, The Learning Organization" by Roth & Kleiner.)

Each EA team member developed field notes of interviews, focus groups, and observations daily and made them available for continual reference among all team members. The team convened to reflect on what was being heard, to review learnings, and to discuss emerging themes on positive practices, enablers, and challenges. Following completion of the field work, team members consolidated themes into a set of team field notes that were reviewed by EA management and shared with the sites. A similar process of shared field notes, reflective journaling, and team writing was employed to jointly analyze the two cases for the common strategic approaches and shared concepts that shaped the final report.

Data Analysis

Qualitative data analysis involves the identification, examination, and interpretation of patterns and themes in textual data and determines how these patterns and themes help answer the study questions at hand. The collected data underwent a data reduction process in order to identify and focus in on what was meaningful. In analyzing qualitative data, it was important to continuously ask the following types of questions:

- What patterns/common themes emerge around specific items in the data?
- Were there any deviations from these patterns, and if so, what factors could explain these atypical responses?
- What interesting stories emerged from the data?
    - Did any of the patterns/emergent themes suggest that additional data needed to be collected?
    - Did any of the study questions require revision?

In order for qualitative data to be analyzable, it must first be grouped into the meaningful patterns and/or themes observed. This process is the core of qualitative data analysis and is generally conducted in two primary ways: content analysis and thematic analysis.

Content analysis includes coding the data for certain words or content, identifying their patterns, and interpreting their meanings. This type of coding is done by going through all of the text and highlighting/labeling words, phrases, and sections of text (using either words or symbols) that relate to the research questions of interest. After the data is coded, it can be sorted and examined to look for patterns. (See "User-Friendly Handbook for Mixed Method Evaluations," National Science Foundation, August 1997.)

Thematic analysis consists of grouping the data into themes that will help answer the study questions. These themes either evolve directly from the study questions or they naturally emerge from the data when the study is conducted, and are pre-set before data collection even begins. Once themes are identified, thematic groups are used to analyze the meaning of the themes and connect them back to the study questions.

Drawing and verifying conclusions are the final steps in qualitative data analysis. They include interpreting what the findings mean, how findings help answer the research questions, and the resulting implications.

To verify conclusions, EA revisited data multiple times for confirmation.

Practical Steps toward Analysis

1. For interviews and focus groups, first record the data by the questions asked.

2. Aggregate the data associated with the respective questions, and examine it for themes and outliers.

3. Compare the themes and outliers from all the questions to synthesize data according to the objectives.

4. During the synthesis of the data by objectives, examine the implications of data related to each objective (sometimes called "binning"), and look at interconnections among the objectives. The themes or outliers within a given objective might illustrate a practice of note. Another view is to look at all the objectives to see whether they interconnect in such a way as to constitute a comprehensive

change approach, or whether they suggest a trajectory toward such a comprehensive approach.

5. Once the binning analysis is complete, identify good practices using the following approach:

    a. A change process element (promising practice) within a given objective bin could be a good practice if:

      i. The element (practice, technique) was found to be used by/at both sites.

      ii. The element was found to be used by only one site, but is consistent with the following success factors identified through the research review:

Success Factors

(EA considered these factors, gleaned from review of scientific and applied literature, as a general framework for evaluating and commenting on effective practices.)

- Change is undertaken as a strategic effort, in contrast to a simple operational change. Strategic problems are typically those that have high stakes and are of critical importance to a firm's success, especially in the long term. A strategic problem may be defined as a deviation from a desired set of specific or a range of acceptable conditions, resulting in a symptom or a web of symptoms recognized as needing to be addressed. Strategic problems, by their very nature, are *complex* and *ill-structured.*

- Change is undertaken with prudence and with full awareness that change, once initiated, cannot be called back and may result in unexpected consequences, unravel long-negotiated organizational stabilities, or open the organization to different scrutiny and new expectations.

- A contingent change process is employed: one that has a formally planned structure but also allows for emergent changes though an adaptive implementation approach that encourages ongoing reflection and learning.

- A distinction is made between problem formulation and problem solving. One of the most important challenges of problem solving is solving the "wrong" problem by adopting a formulation that is either too narrow or inappropriate. Problem formulation is defining the problem to be addressed, whereas problem solving is creating the conditions that can enable the desired future outcomes.

- Problem formulation is comprehensive, where "comprehensive" is defined by the extent to which alternative, relevant problem formulations are identified with respect to an initial symptom or web of symptoms. A comprehensive approach includes both the problem formulation activity and the outcomes. (Note that comprehensiveness does not imply completeness because multiple, competing, yet equally valid views of the problem are plausible.) Alternative problem formulations mean that the organization does not accept a single explanation but instead engages in extensive knowledge probing and critical examination of proposed causal scenarios. Relevance means that the problem formulations are within the organization's capability to act, and that the alternative explanatory scenarios are causally related to the phenomena of concern.

- Heterogeneous teams are used for problem formulation and problem solving. Heterogeneity results from team members being selected with consideration of diversity in their skill and knowledge (e.g., engineering, operations, maintenance, safety, work management) and prior experience, as well as population diversity. Further, active management champion(s) are assigned to support the team(s), and skilled facilitators and team resources are provided.

- Structured processes are used for problem formulation and problem solving. Any number of alternative structured processes could be used to achieve comprehensive problem formulation, as long as the process components satisfy the design goals of mitigating the specific set of impediments.

- Relevant stakeholders are involved in the problem solving process.

- Problem solving considers systemic, process, technical, and human factors and seeks a synergistic balance among the selected improvement interventions. Potential areas of resistance to implementation are considered, as well as indicators of progress/success, and feedback/evaluation support is designed to monitor, adjust, and support the process as progress in change proceeds.

- Problem solving and improvement are understood as learning processes, and learning is an organizational competency nourished, resourced, and sustained as an essential organizational asset.

iii. The change process element was found to be used by only one site but is consistent with the principles and practices of HROs. (Note that such an element would be expected in both the success factors and the HRO principles/practices, since several of the relevant case studies in the reference literature from which the success factors were derived were grounded in HRO research.)

b. A given organization demonstrates elements of all objectives of the EA organizational change management cycle reference model, thus evidencing a maturing or more mature change program than has typically been seen in DOE operations. (Note that EA had no records of change histories at DOE operations to serve as benchmarks, so all reports of change programs and change "success" would be merely anecdotal. EA did inquire whether the organization does have or is compiling a change management learning history that documents what was done, why, and how.)

Organizational Change Management Cycle Reference Model

A cycle model can be used to describe certain functions that must be performed and interact in order to achieve the desired outcome or effect of organizational change. The literature review for this EA study found an absence of any consensus organizational change standard relevant to DOE work types, so EA developed its objectives and lines of inquiry (OLOI) from the literature review and organized them to represent a continuous improvement cycle to support organizational change, as shown in the figure below. EA used this conceptual representation to guide the scope of the inquiry and to sample key elements of organizational change and improvement.

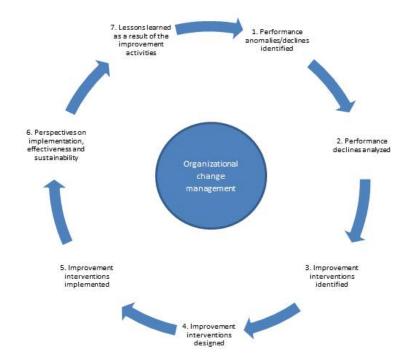# Organizational Change Management Cycle

Figure 1. Organizational Change Management Cycle Model

Capability Maturity Model

As an aid to be mindful of how change efforts may evolve over time and how small steps build on each other over time to support positive change, EA included the concept of the Capability Maturity Model (CMM) in the team orientation and in ongoing discussions about how the organizations were strategically approaching change implementation.

The CMM concept was first established as a development model created after study of data collected from organizations that contracted with the U.S. Department of Defense. The term "maturity" relates to the degree of formality and optimization of processes: from ad hoc practices, to formally defined steps, to managed result metrics, to active optimization of the processes. The original CMM aim was to improve existing software development processes. CMM was subsequently applied to management systems and methods but can also be applied to other processes, including change management – for example, in the Prosci change methods, a 2014 study by IBM, and a study by the independent professional association, the Change Management Institute. The CMM concept also appears in IAEA safety culture documents. No equivalent body of collected knowledge exists for organizational change management in nuclear-related domains. For the purposes of the EA analysis, the maturity concept proved useful as a conceptual reference, if not a specific measurement device. As a particular reference point, the CMM concept played a role in the discussion of good practices. (Note that DOE has used the CMM concept in the context of the EFCOG Human Performance collaboration and in the EFCOG CAS Maturity Evaluation Tool.)