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Advanced Nuclear Technology: Using Technology for Small Modular Reactor Staff Optimization, Improved Effectiveness, and Cost Containment

2016 TECHNICAL REPORT

Advanced Nuclear Technology: Using Technology for Small Modular Reactor Staff Optimization, Improved Effectiveness, and Cost Containment

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NOTE

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These utility and vendor members of EPRI, designers/suppliers of small modular reactors (SMR), engineering services suppliers, nuclear industry organizations, DOE personnel, and industry professionals supported and guided this project. Some TAG members participated in meetings, while others monitored project distributions and provided selected comments.

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REPORT SUMMARY

A key need for the economic viability of small modular reactors (SMR) is the ability to safely operate and maintain the plant with an optimized staff. Total operation and maintenance (O&M) costs of SMR must be contained, and reduced where appropriate. The subject of this report is the potential for staff optimization at SMR through the application of selected technologies and design details. The report presents the results of a collaborative project that systematically reviewed a range of staff functional areas to identify technologies with staffing impact. The project selected, evaluated, and documented 25 technologies that show significant potential to support staff optimization.

Background
Small modular reactors offer the potential for a viable, robust, and dependable source of electric generation that can help meet the nation's economic, energy security, and environmental goals by replacing the electric generation capacity of retiring fossil plants. They also offer a viable, robust, and dependable source of electric generation in grid arrangements populated with intermittent sources such as wind and solar. Their advantages include lower initial capital investment compared to large nuclear projects; scalability; and siting flexibility at locations unable to accommodate larger reactors. Designs to date show the potential for enhanced nuclear safety and security. These factors contribute to making SMR desirable and economically feasible. However, to make SMR truly viable, their operating and maintenance costs must be contained, while meeting all requirements for safe, reliable nuclear operation.

Objective
The objective of this project is to perform a systematic analysis of several nuclear plant functional areas to determine technologies and design details that can be applied to those areas to safely optimize the number of people needed to operate the plant.

Approach
Concepts for staff reduction at SMR were identified and characterized in a multistep process. The process used expertise and resources from a Technical Advisory Group (TAG) composed of experienced nuclear power industry operations personnel, current designers of SMR plants, industry engineering organizations, and EPRI technical experts within each of the staff areas examined. For purposes of the investigation, overall plant operational roles were organized into 10 major functional areas.

Functionally, the process was designed to solicit input and counsel from the TAG on identification of, and requirements for, Technologies and Design Details (TDDs) that would enable SMR staffing optimization. The primary elicitation of information occurred during a set of in-person meetings among the TAG, Subject Matter Experts (SME), and EPRI project staff.

Results

The project identified, evaluated, and documented 25 Technologies and/or Design Details that when implemented would substantially reduce the staffing required for evolving SMR plants. These TDDs embrace work functions from the 10 plant functional areas (numbers in parentheses represent the number of TDDs selected for each given area):

- Chemistry (3)
- Radiation Protection (4)
- Maintenance (5)
- Engineering (3)
- Operations (2)
- Outage Management (0)
- Training (1)
- Emergency Preparedness (2)
- Warehousing and Supply Chain (2)
- Security (3)

The report is structured so that Owner/Operators, SMR designers, Engineering Procurement and Construction contractors, industry regulatory support groups, and related Research and Development groups can each take specific actions to achieve the benefits of the TDDs.

Applications, Value, and Use

The EPRI Advanced Nuclear Technology Program advisors and the U.S. Department of Energy Office of Nuclear Energy, understanding the importance of SMR to achieving U.S. goals of improving the economy through job creation, meeting greenhouse gas reduction mandates, and assuring domestic energy security, directed that this project be carried out. The needed insights were drawn from many individuals and organizations of the nuclear industry. The EPRI collaborative model for advancing technical understanding and cooperation was essential to the success of the project.

The contents of this report are intended to be used by, and useful to, potential Owner/Operators, SMR design teams, industry R&D organizations, and industry regulatory support groups.

Keywords

Nuclear plant design
Nuclear plant staffing
Small modular reactors
Staff optimization
Technology development

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1 INTRODUCTION

1.1 Background

Small modular reactors (SMR) offer the potential for a viable, robust, dependable source of electric generation that can help meet the nation's economic, energy security, and environmental goals by replacing the electric generation capacity of retiring fossil plants. They also offer a viable, robust, and dependable source of electric generation in grid arrangements populated with intermittent sources such as wind and solar. Their advantages include lower initial capital investment compared to large nuclear projects; scalability; and siting flexibility at locations unable to accommodate larger reactors. Designs to date show the potential for enhanced nuclear safety and security. These factors contribute to making SMR desirable and economically feasible. However, to make SMR truly viable, their operating and maintenance costs must be contained, while meeting all requirements for safe, reliable nuclear operation.

Therefore, a key need for SMR economic viability is the ability to safely operate and maintain the plant with an optimized staff. Total operation and maintenance (O&M) costs of SMR must be contained, and reduced where appropriate. Paths and options to achieve this condition are needed.

Current nuclear power plant staffing functions, tasks, and resource levels are based upon existing requirements, codes, and regulations and on the operating experience of existing large Light Water Reactor (LWR) technology plants. SMR plants are designed with a smaller site size, increased use of automation technologies, reduced numbers of systems and components, and passive designs requiring less operator intervention. These unique characteristics will change the roles, responsibilities, functions, and tasks of typical site staffing positions and provide an opportunity for optimization and possible O&M cost reductions.

The EPRI Advanced Nuclear Technology (ANT) Program previously investigated staff optimization for new nuclear power plants as documented in EPRI report 1011717, *Staff Optimization Scoping Study for New Nuclear Power Plants*. While this report targeted Advanced LWRs (ALWRs), it noted that there is indeed a potential for staff optimization in the large plants through technology application. The study also concluded that, while staff reductions can be effected via technology and organizational improvements, full optimization can only be accomplished through full consideration of human factor elements during the design phase of the plant development process. Additionally, EPRI has considered the application of similar technology for cost reduction in EPRI report 1015087, *Instrumentation and Control Strategies for Plant-Wide and Fleet-Wide Cost Reduction*. That document primarily addresses the existing fleet of power reactors. Task analysis results show that comprehensive instrumentation and control (I&C) modernization can generate as much as an 18% reduction in O&M staff. For existing plants, this level of savings requires a substantial modernization investment, but as the SMR are designed and deployed, there is an opportunity to build the needed infrastructure into the initial design.

1.2 Purpose and Goals

The overall objective of this project is to perform a systematic analysis of several nuclear plant functional areas to determine technologies that can be applied to those areas to safely optimize the number of people needed to operate the plant.

Specific project objectives are the following:

- Definition and prioritization of specific technologies and design details that if pursued can achieve projected optimizations in staffing. Users will be:
  - SMR design teams
  - Potential Owner/Operators
- Definition and prioritization of staffing-related functions that show strong potential for staffing optimization but require additional evaluation and development to determine the necessary specific technologies and design details. Users will be:
  - SMR design teams
  - EPRI, U.S. Department of Energy (DOE), and other R&D managers
- Development of a logic model that supports ongoing decision making to achieve further staffing optimization and to evaluate related efforts. The model should help SMR project and plant personnel better understand the staffing impacts of technical decisions. Data needed to enable the model will be identified and provided as available. Users would be:
  - Owners/Operators for specific project and plant decision making
  - EPRI, DOE, and other teams that carry this analysis forward

1.3 Report Structure

The approach to this project and the structure of this report are intended to create action and to move the identified Technology and Design Details (TDD) concepts forward.

The TDD Writers' Guide (Appendix B) specifies:

> A TDD, properly completed, should contain sufficient detail that a competent design organization could understand the intent and expectations of the TDD and proceed to perform the evaluations and create the technical details necessary to incorporate the TDD into a plant design. If the subject of the TDD needs further development, the TDD should contain sufficient details that a competent research and development organization could understand the development needs and pursue necessary projects to make the subject of the TDD usable on a project.

To support this expectation, the remainder of this report is structured as follows:

- Section 2 captures the approach and mechanics used by the project to probe plant functional areas, identify topics of value, and document meaningful information in TDD format. Methods of documentation and decision making are discussed in detail. Overarching project concepts are also detailed.
- Section 3 describes for each plant functional area the essential information of each TDD selected. It provides summaries and observations to help describe the value of each TDD.
- Section 4 drives directly to the specific TDDs that can be acted on by each potential user. Potential users are Owner/Operators; SMR designers; Engineering, Procurement, and Construction (EPC) groups; industry regulatory support groups; and related Research and Development groups. Applicability of TDDs to currently operating plants and evolving ALWR is included.
- Section 5 provides a prioritized overview of the TDDs and consolidates multiple TDDs under five global technology topics that span a number of TDDs and plant functional areas. Achieving maximum benefit from many of these TDD concepts requires that they be holistically implemented and/or developed in a coordinated fashion.

The appendices to the report capture details that are essential to full use of the TDDs but beyond the level of detail necessary for the general report:

- Appendix A contains a detailed listing of all specific functions within each of the plant staff functional areas that were evaluated under this project.
- Appendix B presents the Writers' Guide that describes the intent of each of the content portions of the TDD. Understanding the Writers' Guide is essential to understanding the details of the TDD.
- Appendix C contains the full content of each of the 25 TDDs, as populated by the project.
- Appendix D documents the model describing the "due diligence" that is necessary to move from technical idea to staffing improvement.
- Appendix E characterizes each of the TDDs in accordance with the EPRI Technology Readiness Level scale.

2
PROJECT APPROACH, INTENDED USES, AND OVERARCHING CONCEPTS

2.1 Project Approach

Concepts for staff optimization at SMR were identified and characterized in a multistep process. The process used expertise and resources from a Technical Advisory Group (TAG) composed of experienced nuclear power industry operations personnel, current designers of SMR plants, and members of industry engineering organizations. The TAG was supplemented by Subject Matter Experts (SME) in each of the staff areas examined.

For purposes of the investigation, overall plant operational roles were organized into ten major plant staffing areas:

- Chemistry
- Radiation Protection
- Maintenance
- Engineering
- Operations
- Outage Management
- Training
- Emergency Preparedness
- Warehousing and Supply Chain
- Security

Based on the staffing structure at an operating nuclear power plant, a list of functional responsibilities was created for each of these ten plant areas. The functional responsibilities within each of these plant areas served as the framework for identifying the specific nuclear power plant staff activities that could be optimized. A listing of the functional responsibilities considered for each plant area by the project is provided in Appendix A.

A multistep process, depicted in Figure 2-1, was used to identify and characterize technologies and design details (TDD) that could provide SMR staff effectiveness improvements while accomplishing staff reductions.

Functionally, the process was designed to solicit input and counsel from the TAG on identification of, and requirements for, TDDs. The primary elicitation of information occurred during a set of in-person meetings among the TAG, Subject Matter Experts (SME) and EPRI project staff. Each meeting was devoted to a subset of the major plant staffing areas. The coverages and dates were as follows:

- Chemistry/Radiation Protection: March 31–April 1, 2015
- Maintenance/Engineering: June 9–10, 2015
- Operations/Training/Outage Management: August 25–26, 2015
- Warehousing/Supply Chain/Emergency Preparedness/Security: December 1–2, 2015

As shown in Figure 2-1, each meeting was conducted using an elicitation and prioritization process, with resulting key points documented in draft TDDs. Both SME and TAG members performed pre-meeting preparation to maximize the accomplishment during each meeting.

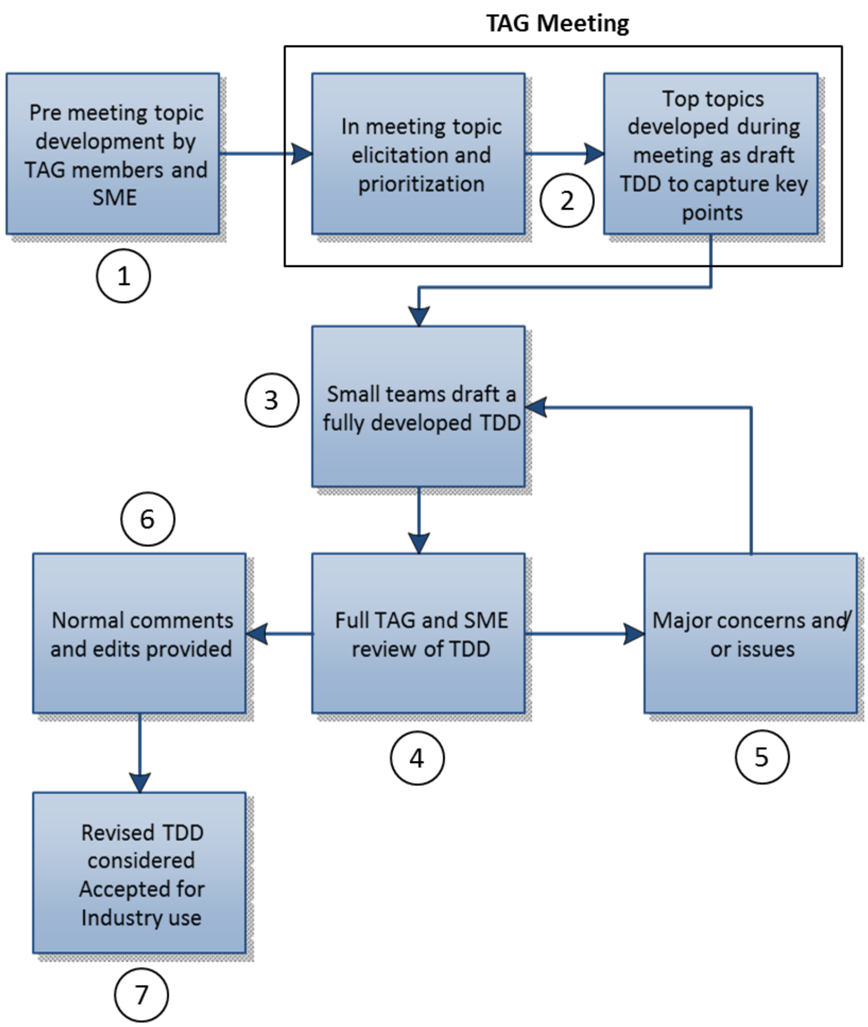


Figure 2-1
SMR staffing TDD development process

TAG members and SME were polled in-session to identify candidate technologies for staff optimization, considering the staffing levels at existing nuclear power plants, SMR design characteristics, and available or emerging technologies that could be applied. Results of this polling were documented in data capture tables for each of the major plant staffing areas; data entries and guidance used to develop data are shown in Figure 2-2.

Since specific staffing levels are considered proprietary to individual designs, and in some cases are still being fully developed by the designers, the staffing levels of SMR were not known to the TAG. Staffing quantitative impacts were estimated considering the staffing requirements of a well-run current-generation plant. The intent was to have a common gauge of the relative impact of a TDD so that the TDDs could be compared among themselves. Therefore, the staffing impacts listed are not the absolute impact numbers for an SMR plant.

To encourage aggressive, innovative thinking by all persons involved with the project, the TAG was challenged to assume that the technologies and design details identified must support a total site SMR staffing of 100 persons. In this concept, each plant function would be allowed its proportional share to the 100 based on current ALWR allocation of staff among plant functional groups. Therefore, when considering Engineering (for example) SMR staffing was targeted to be 16 full-time equivalent (FTE).

The development effort considered was the effort to make the TDD concept ready for incorporation into a plant design, not the effort to incorporate the TDD details into the SMR design.

Staff Reduction Technology		Applies SMR? Yes/No	Net Impact H/L[1]	Effort to Develop H/L[2]	Rank (A/B/C/D)[3]	Notes and Comments
No.	Description					

1. Preliminary Net Impact (including offsets, if any):
   High – At least 5 FTE
   Low – Less than 5 FTE
2. Preliminary Development Net Effort:
   High > $5M (note: 5 FTE @ 200k/FTE per year with 5 year payback)
   Low < $5M
3. Initial Rank based on the matrix:

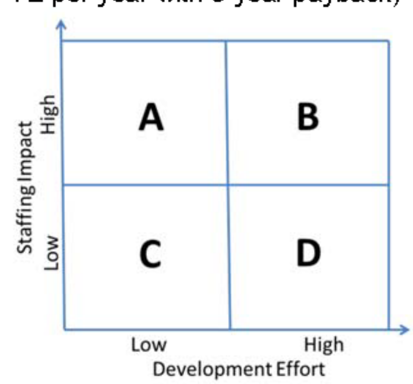


Figure 2-2
Staff reduction data capture table

Top-priority topics were identified—based on the initial rank and the sense of the TAG regarding potential staff reduction effectiveness—for further evaluation during the meeting. Draft TDD descriptions were then developed for the selected topics to document key points identified by the meeting participants. Information sought for each TDD is described in the TDD Writers' Guide (Appendix B); draft TDD sheets were populated to capture critical TAG insights on the topic while the group was in session. Actions for completing and validating data entries were assigned to a small group of TAG members, SME, and the EPRI project staff. These conversations also served to highlight regulatory issues, potential deployment constraints or challenges, developmental work required, and previous EPRI/industry work that has been done pursuant to some TDDs.

Following the meetings, the small teams (identified uniquely for each TDD) refined data entries and produced completed draft TDDs. Full TAG and SME reviews were conducted on these drafts, and, as required, TDDs were revised to address major concerns and/or issues identified during the review. Once finalized through TAG review, the TDDs were considered accepted and ready for industry use.

Results of applying this process for each of the major plant staffing areas are discussed in Section 3.

2.2 Intended Uses of This Report

The contents of this report are intended to be used by, and useful to, several end users:

1. Designers of SMR plants and the Engineering, Procurement, and Construction (EPC) consortiums of which they may be members are primary users of this report. Their uses should include:
   – Serious consideration of each TDD for applicability to their SMR basic conceptual approach. Section 4.1 contains a breakout of TDDs ready for SMR design action.
   – Incorporation of the TDD statement and supporting assumptions (design, construction, and operational) into the necessary design basis documents that guide and document their plant design.
   – Translation of these design basis document requirements into the supporting procurement specifications and construction instructions for the project.
2. Owner/Operators of SMR plants are intended users of this report. Their uses should include:
   – Serious consideration of each TDD for inclusion into the SMR plant they are considering for purchase.
   – Advising potential SMR bidders of their desire to have these capabilities in any project plan proposed.
   – Incorporation of desired TDD capabilities and supporting assumptions into project SMR request for quotation (RFQ) technical requirements.

  - Incorporation of desired TDD capabilities and supporting assumptions into selected SMR vendor contractual technical requirements.
  - Assuring that planned and actual plant organizational structures and functions maximize use of the incorporated TDD capabilities and sustain the effectiveness of the capabilities.
3. Research and Development organizations, specifically the U.S. Department of Energy Office of Nuclear Energy and EPRI, but also any other interested R&D organizations, are intended users of this report. Their uses should include:
   - Each TDD should be reviewed to identify the Enhanced and Essential development tasks that have been called out in the TDD. Section 4.3 of this report contains a breakout of these needs.
   - Once these needs have been prioritized, specific projects should be pursued to supply the information/capability needed to allow the TDD to be fully implemented by SMR design organizations.
4. Industry groups such as NEI (Nuclear Energy Institute), INPO (Institute of Nuclear Power Operations), WANO (World Association of Nuclear Operators), and IAEA (International Atomic Energy Agency) are intended users of this report. Their uses should include:
   - Review of the TDDs to identify needed regulatory and policy action to allow or enable use of the TDD concept. Section 4.4 of this report contains a breakout of these needs.
   - Consideration of regulatory and policy initiatives already underway, taking into account the TDD needs in these efforts.
   - Creation of new regulatory and policy initiatives to address TDD needs if they do not fit appropriately with other work underway.

2.3 International Applicability of This Report

This report, the Technology and Design Details as documented, and the insights and results summarized by the project are fully usable by international EPRI members. References to regulators and regulations in the report are general in nature but should be viewed from the perspective of groups responsible for regulation of nuclear power plants in each country.

2.4 Overarching Project Concepts

The project identified early on that:

1. Technical concept effectiveness would be dependent on the holistic application of the concept throughout the project including design, procurement, project management, construction, and plant operations.
2. Some of the more impactful concepts would span multiple staffing areas.

Given these two realities, the following overarching concepts were established as fundamental assumptions for the environment within which TDDs would be implemented. Without these concepts in place, the individual TDDs detailed in this report will not achieve their full potential in optimizing staffing for small modular reactors.

- Cross-training of plant staff in multiple disciplines and tasks is essential to operating with an optimum staff size. New and evolving reactor designs have the opportunity to "redefine" functions and staff utilization.
  - Cross-training of staff should be the expectation, not the exception.
  - Current very successful groups such as the U.S. Navy Nuclear Program and the operation of the large and expanding fleets of natural gas power plants reinforce the value of staff cross-training.
- Design details must be maintained current and must feed plant programs and organizational needs seamlessly.
  - Start with the end in mind. The operating staff of a plant should not have to supplement or reconfigure plant data to fit the needs of established industry programs or functional needs to operate the plant.
- Remote support of plant functions by "fleet" capabilities is essential to minimizing dedicated staff at a given plant.
  - Many of the functions required for operation of an SMR are readily performed on a fleet basis serving multiple plants and locations.
  - Capabilities may be dispersed among multiple plant and vendor locations.
  - Strong data and image interconnectivity is essential for fleet support to be effective.
- Fully developed and mutually compatible digital controls, monitoring, analytic, reporting, and archival systems are an essential backbone for effective and efficient operation of the plant.
  - These systems must be based on an accurate understanding of the functional needs of the individual plant users.
  - Plant functional organizations must fully embrace, incorporate, and exploit the capabilities of these systems in their processes and procedures.
  - The outputs of these systems must be decision-quality information, meaning that any authorized member of the staff can confidently act on the information as provided.
  - Cyber security must be an integral aspect of the design, fabrication, installation, maintenance, and operation of these systems.
- Connectivity (excluding plant controls) from and among all necessary plant areas and capabilities (with appropriate cyber security measures) is an essential capability to optimize plant staff size and effectiveness.
  - The connectivity is assumed to be wireless wherever possible, thereby maximizing flexibility and utility.
  - The envisioned connectivity eliminates as many barriers as possible between the work point, the information, and the authorizations needed to perform work.
  - The outputs of this connectivity must be decision-quality information, meaning that any authorized member of the staff can act on the information as provided.

- Plant data-centric configuration management processes, access, use, and maintenance must be fully digitally integrated into all related plant activities on a real-time basis. This capability must be supported by an industry common plant information model.
  - A three-dimensional (3-D) model of the plant must be created during plant design and maintained accurate throughout plant construction and operation.
  - The integrity of the configuration management processes and content must be of the highest order.
    - Recovery processes must be in place to minimize (limit) the impact to the project and/or the plant when errors in the configuration management processes and content are identified.
  - Plant functional organizations must fully embrace, incorporate, and exploit the capabilities of the configuration management system and its interactive databases in their processes and procedures.
    - The synergy of these systems, their information, and their connectivity creates compounding value at many levels within the plant and the project.

3

STAFFING OPTIMZATION CONCEPTS BY PLANT AREA

This section provides results of applying the approach described in Section 2 to develop SMR staff optimization concepts as captured in TDDs. The TDDs are categorized in the following subsections by major plant staffing area. Each discussion includes the following:

- Staff reduction technologies identified and considered (data capture sheets)
- Technologies selected for detailed characterization in TDDs
- Overarching concepts noted for the staffing area
- Key insights for achieving the staffing benefits identified

3.1 Chemistry

3.1.1 Staff Reduction Technologies

Potential staff reduction technologies identified for chemistry are listed in Table 3-1.

As noted in the table, only technology C1 was judged to rank higher than "C" on the combined development effort/staff reduction potential matrix. Technologies C9 through C15 were not developed further because the general opinion of the TAG was that these would have only limited potential for staff reductions as compared to those applicable to C1 through C8.

Table 3-1
Data capture table: chemistry

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	Description			
C1	Automated Sampling and Analysis – Chemical	H	H	B
C2	Automated Sampling and Analysis – Radiological	L	L	C
C3	Chemical and Radiological Analysis Software Suite	L	L	C
C4	Automated chemical addition	L	L	C
C5	Automated radiochemical count lab	L	L	C
C6	Continuous De-lithium	L-	L	C
C7	Radwaste handling (processing through shipping)	L	L	C

Table 3-1 (continued)
Data capture table: chemistry

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	Description			
C8	Automated effluent (water & air) monitoring	L	L	C
C9	Automated environmental monitoring	*	*	*
C10	Use contractors in combination with technology	*	*	*
C11	Reduction in number of aux systems	*	*	*
C12	Automated feedwater sampling/monitoring	*	*	*
C13	Automated tritium analysis	*	*	*
C14	Automated sewage outfall monitoring	*	*	*
C15	Revise EPRI Chemical guidelines to reflect SMR design advantages	*	*	*

* Not developed further

3.1.2 Technologies Selected for TDDs

Technologies C1, C2, and C3 were selected for development of detailed information in TDDs.

Although C1 was the only technology ranked higher than "C," it was recognized that there are notable synergies among C1 through C3, so all three of these technologies were brought forward for further consideration. Descriptions of the selected technologies and design details follow.

<u>C1 – Automated Sampling and Analysis – Chemical</u>
Real-time, online, automated (e.g., calibration), high reliability process fluid sampling, analysis and reporting capability based on primary, secondary, and auxiliary water chemistry parameters from EPRI and original equipment manufacturer (OEM) guidelines. The system would be integrated across all units/modules and be compatible with off-site monitoring and management of chemistry parameters.

<u>C2 – Automated Sampling and Analysis – Radiological</u>
Real-time, online, automated (e.g., calibration), high reliability sampling, analysis, and reporting capability for in-plant systems radiological parameters including online gamma spectroscopic analysis and primary loop Nitrogen-16 off-gas monitoring. The system would be integrated across all units/modules and be compatible with off-site monitoring and management of radiological parameters.

<u>C3 – Chemical and Radiological Analysis Software Suite</u>
Software suite that performs all data reduction, analysis, and reporting for chemistry and in-system radiological monitoring functions, and generates reports in forms and content suitable for multiple (all) users.

3.1.3 Overarching Concepts

A primary theme in these technologies is the automation of monitoring, analysis, and reporting of chemical and radiochemical parameters in the primary and secondary loops, as well as for effluent and environmental monitoring.

During the project evaluation of Chemistry functions, it was determined that the entire plant chemistry function could be performed remotely but would probably require some minimum on-site presence. This assumes that chemistry-related information provided to the plant is decision-grade, allowing plant actions to be taken as required given the nature of the information. This includes decision making during the early stages of a declared emergency. It also assumes that Operations or other plant staff are sufficiently cross-trained to routinely perform chemical addition tasks.

It is noteworthy that SME present during discussions on these TDDs concluded that these capabilities in combination will eliminate the need for “any” chemistry shift coverage.

3.1.4 Key Insights

Staffing benefits potentially achievable through these technologies will involve trade-offs between reduction of staff required to manually conduct sampling and monitoring activities and increases in I&C staff necessary to maintain and calibrate additional monitoring equipment and instrumentation.

Elimination of shift chemistry technicians will require operators to perform chemical addition tasks. This should not be a problem given training and cross-training.

There are linkages and synergies among the three chemistry TDDs, such that staff reductions will be optimized more effectively if all of them are implemented in a coordinated fashion.

3.2 Radiation Protection

3.2.1 Staff Reduction Technologies

Potential staff reduction technologies identified for radiation protection are listed in Table 3-2.

As noted in the table, four of the technologies had priority rank “A,” with the balance of the technologies ranked “C” or lower.

Table 3-2
Data capture table: radiation protection

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	Description			
RP1	Personnel Access – decrease processing and escorting by use of better focused training content	L	L	C
RP2	Eliminate and/or reduce radiation monitors daily response checks frequency and scope of calibration (portable and fixed)	L	L	C
RP3	Automated Personnel Monitoring and Dosimetry	H	L	A
RP4	Automated ALARA Job Reviews and RWP Generation	H	L	A
RP5	Automated Radiation Monitoring and Analysis	H	L	A
RP6	Data analysis – 3D modeling, GPS locating	*	*	*
RP7	Robotics for survey conduct (design expectations)	L	H	D
RP8	Staff cross training for surveys			
RP9	Automated Public Dose Assessment for EP	H	L	A
RP10	Coatings et al. for easier decontamination	L	L	C
RP11	Standard radiation points for SMR – instrumentation and monitoring locations	L	L	C
RP12	Automated material release	L	H	D

* Incorporated into RP3, RP4, and RP5

3.2.2 Technologies Selected for TDDs

Technologies RP3, RP4, RP5, and RP9 were selected for development of detailed information in TDDs. Each of these were top "A" ranked and were projected to provide potentially significant staffing impact with relatively low development effort.

After discussion, it was determined that the technology anticipated in technology RP6 (three-dimensional plant modeling and local positioning system) is foundational to RP3, RP4, and RP5. Accordingly, the technical capability anticipated for RP6 was incorporated into each of these technologies in developing the draft TDDs.

Descriptions of the selected technologies and design details follow.

<u>RP3 – Automated Personnel Monitoring and Dosimetry</u>
Real-time, automated (e.g., calibration), high-reliability personnel monitoring and dosimetry capability, including:

- Remote monitor capability for visual observation of work and communication with personnel
- Electronic reporting and documentation (e.g., electronic teledosimetry shift log)
- Internal Positioning System (IPS) with personnel and equipment location and mapping capability
- IPS-compatible, configuration controlled, three-dimensional (3-D) plant model

The system would be integrated across all units/modules and provide for off-site observation and management of personnel doing radiological work and associated dosimetry.

<u>RP4 – Automated ALARA Job Reviews and RWP Generation</u>
Fully automated ALARA job reviews and RWP generation, including incorporation of operational experience and data from electronic database developed from automated dosimetry and personnel monitoring systems (TDD-RP3) and automated radiation surveys and dose calculations (TDD-RP5).

<u>RP5 – Automated Radiation Monitoring and Analysis</u>
Real-time, automated (e.g., calibration), high-reliability capability for plant radiation monitoring and analysis, including:

- Area monitors and continuous air monitors and associated data feeds
- Electronic analysis, reporting and documentation of monitoring results
- Dose model and dose rate calculations
- Reaction to emergency action level threshold values

The system would be Integrated across all units/modules and be compatible with off-site observation and management of personnel doing radiological work and associated dosimetry.

<u>RP9 – Automated Public Dose Assessment for EP</u>
Automated public dose assessment incorporating real-time, automated meteorological and radiation monitoring data for EP support during emergencies, with the objective of eliminating on-shift staffing driven solely by EP requirements (e.g., minimize need for roving monitoring teams).

3.2.3 Overarching Concepts

Radiation Protection function optimization revolved around an ongoing and on-demand ability to remotely determine the radiological and environmental condition of any given plant area. The integrity of the analytical models to accomplish this and related analysis are key to this capability.

Three-dimensional plant modeling and local positioning system capability is foundational to RP3, RP4, and RP5. Accordingly, this technical capability is necessary for many technologies to achieve staff reduction. The overall effectiveness of implementing such systems can be leveraged more effectively if RP3, RP4, and RP5 are implemented simultaneously.

3.2.4 Key Insights

Significant work that has been completed or is underway in the EPRI Chemistry, Low Level Waste, and Radiation Monitoring Programs moves this technology forward.

3.3 Maintenance

3.3.1 Staff Reduction Technologies

Potential staff reduction technologies identified for maintenance are listed in Table 3-3.

Table 3-3
Data capture table: maintenance

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	Description			
M1	Standardized Components	H	L	A
M2	Cross-Training of Maintenance Staff	H	H	B
M3	Connectivity	H	L	A
M4	Automated Electronic Mobile Work Management	H	L	A
M5	Design for Maintenance Effectiveness and Efficiency	L	L	C

3.3.2 Technologies Selected for TDDs

All five staff reduction technologies were selected for development of detailed information in TDDs. Technologies M1, M3, and M4 were ranked “A” and were projected to provide potentially high staffing impact with relatively low development effort.

Although ranked “B,” TDD M2 was viewed as having the potential for a large overall decrease in staffing, as well as allowing for additional reductions in other staffing areas (e.g., work planning, radiation protection, quality control, and operations).

Technology M5 was also retained for further detailed development, because it was judged to have, beyond the low staffing impact in routine operations, the potential for more significant savings from efficiencies gained during major plant maintenance (e.g., large component replacement, refueling outages).

Descriptions of the selected technologies and design details follow.

<u>M1 – Standardized Components</u>
Reduce maintenance staff, number of qualifications, and plant complexity by limiting the number of unique (type, make & model) components in plant design. This will enable a rapid remove-and-replace overall maintenance philosophy.

M2 – Cross-Training of Maintenance Staff
Use of multi-skilled personnel for maintenance functions, inspection functions, radiation protection functions and some engineering functions. Craft will be experienced (including non-licensed operators) and cross-qualified in various aspects of mechanical, electrical and instrumentation maintenance tasks.

M3 – Connectivity
Maintain a central repository database of plant/plant component and training/qualification information with associated analysis and reporting capability. Install wireless communications capability for 100% coverage during build to allow staff access to central plant database throughout plant life. Choose an Enterprise Asset Management (EAM) System with specifications that will enable and ensure: tablet use in field, automated training verification, parts tracking, re-order and re-stocking, automated update to scheduling tool (i.e., Primavera), procedure validation and current-version availability, compiled component information, clearance sign-on, operations approval, as-found and as-left entry, real-time revision capability, worker tracking, trouble-shooting information, interaction with SMEs on and off job site, and plant logs. Use of the above processes will allow reductions in warehouse, training, planning, operations and work management staff.

M4 – Automated Electronic Mobile Work Management
Implement an automated, electronic, work management/planning system that incorporates wireless technology. Processes should include standard work orders, real time revision and approval capability, and worker tracking. The system would be linked with the work management planning system (e.g., Maximo software) and to the plant data repository and/or central digital data repository (TDD-M-3).

M5 – Design for Maintenance Effectiveness and Efficiency
Concurrent consideration for maintenance/replacement needs during all stages of plant design evolution to optimize maintainability and facilitate component replacement throughout plant life.

3.3.3 Overarching Concepts

Technology approaches for maintenance TDDs fall into three overall categories:

- Cross-training of staff to optimize flexibility through broadening individuals' span of capability
- Optimizing maintenance activities through consideration during design and maximizing use of standardized components
- Use of 3-D plant modeling, central plant condition and configuration databases, remote monitoring and planning, and plantwide connectivity to optimize maintenance activities

3.3.4 Key Insights

There are linkages and synergies between TDDs M3 and M4 and other TDDs that involve 3-D plant modeling, central plant condition and configuration databases, remote monitoring and planning, and plantwide connectivity. Accordingly, staff reductions could be optimized more effectively if all of them are implemented in a coordinated fashion.

TDD M2 specifically addresses the benefits of cross-training in Maintenance. As noted in Section 2.4, the project believes that opportunities for cross-training exist in and among all plant functions. Each of these will lead to further staffing improvements.

3.4 Engineering

3.4.1 Staff Reduction Technologies

Potential staff reduction technologies identified for engineering are listed in Table 3-4.

Table 3-4
Data capture table: engineering

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	Description			
E1	Engineering Tools	H	H	B
E2	Automated Plant Health Management System Assuring Plant and Equipment Reliability	H	L	A
E3	Program Engineering Automation	H	L	A

3.4.2 Technologies Selected for TDDs

All three staff reduction technologies were selected for development of detailed information in TDDs. Technologies E2 and E3 were ranked "A" and were projected to provide potentially high staffing impact with relatively low development effort.

Technology E2 was estimated to have a limited impact when viewed solely for decreasing engineering staffing. However, the technology could achieve high levels of plant reliability while containing maintenance cost (reduced number and content of preventive maintenance tasks as well as reduced corrective maintenance), so it was retained for TDD development. Improved plant reliability reduces engineering workload and associated engineering staffing.

A high degree of staff reduction is expected if Technology E1 is applied without full 10 CFR 50 Appendix B certification, and even greater reductions are possible if full certification is achieved. The levels of development would be high if full Appendix B (or an equivalent international quality requirement) capability is provided and low if existing levels of quality certification are maintained. In either case, staff reduction potential of this technology was judged to qualify it for full TDD development.

Descriptions of the selected technologies and design details follow.

<u>E1 – Engineering Tools</u>
Integrated suite of cross-functional technical tools that is interoperable with the plant CMIS (Configuration Management Information System) that will assure that the owner/operator of the plant maintains to the extent practical and realistic the engineering tool set used by the EPC contractor during plant development. This capability will enable cross-checking of design details of various disciplines during the original design and design change processes. The suite would be a data-centric system maintained from design through operations. It would provide a functional tool for plant design engineering and a reference tool for the remainder of plant staff. It would use a "single source of truth" concept where each item is stored once and used across the design assuring that all design cases have fidelity.

<u>E2 – Automated Plant Health Management System Assuring Plant and Equipment Reliability</u>
Automated system using plant connectivity established under TDD M3 to provide automated monitoring and analysis of component and system performance data, sufficient to satisfy plant health monitoring and reporting requirements. This capability will also provide plant system health information needed to assure plant and equipment reliability (e.g., pump vibrational data and bearing temperatures). System includes automated troubleshooting that incorporates known system and component troubleshooting and failure mode information as well as more sophisticated analysis and evaluations, such as comparison of performance data to norms, such as pump curves or trend information.

<u>E3 – Program Engineering Automation</u>
Incorporation of component and system instrumentation necessary for collection of, automated analysis of, and reporting of monitored data for components and systems subject to mandatory program requirements (e.g., motor-operated valves [MOV], air-operated valves [AOV], check valves, heat exchangers, pump performance).

3.4.3 Overarching Concepts

Technologies E2 and E3 involve deployment of tools, plant components, and systems that enable automated monitoring and update of plant conditions required for engineering functions and automated performance of such functions.

Technology E1 would capitalize on use of 3-D plant modeling, plant information model databases, data-centric real-time plant information, and evolving engineering tool sets to achieve engineering staffing optimization.

3.4.4 Key Insights

There are linkages and synergies between TDDs E1, E2, E3, and other TDDs that involve 3-D plant modeling, central plant condition and configuration databases, remote monitoring and planning, and plantwide connectivity. Accordingly, staff reductions could be optimized more effectively if all of them are implemented in a coordinated fashion.

3.5 Operations

3.5.1 Staff Reduction Technologies

Potential staff reduction technologies identified for operations are listed in Table 3-5.

Table 3-5
Data capture table: operations

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	Description			
O1	Intelligent Configuration Management Optimization	H	L	A
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures	H	H	B
O3	Remote visual inspections	L	L	C
O4	Physical Orientation to support Operations	*		
O5	Maximizing Passive Systems and minimizing active components	*		

* Considered part of existing plant design process

3.5.2 Technologies Selected for TDDs

Technologies O1 and O2 were selected for development of detailed information in TDDs, because each of these is projected to provide a large potential reduction in staffing.

Technology O3 was projected to provide for only a small reduction in operations staff, and some of the intended functionality is captured in other TDDs. Both technologies O4 and O5 were considered part of the existing SMR design process and therefore do not provide opportunities for additional staff optimization.

Descriptions of the selected technologies and design details follow.

O1 – Intelligent Configuration Management Optimization
Install technical capabilities and plant 3D models allowing determination of the physical status of plant configuration at any time. This results in minimizing the need for field verifications and for operators to physically go to specific locations confirming status of components. This capability must address operational workload associated with outages and outage recovery, as well as other major changes of plant condition. Portions of the plant infrequently changed may not require this capability. All associated information must be decision quality.

O2 – Automation of monitoring, analysis, operational functions including Electronic Procedures
Necessary integration and automation of plant information to support Operation's needs to monitor and analyze plant data to allow enhanced plant automated functions, the effective use of electronic procedures and automation of plant logs including narrative entries. This capability will provide support under normal and abnormal plant conditions. Is assumed to be accessible to, usable by and where necessary used to support Engineering, Maintenance and other plant monitoring and analysis capabilities. Wireless transmission of data enhances this capability.

3.5.3 Overarching Concepts

Both operational technologies involve achieving a high degree of ability to automatically and remotely monitor plant conditions and to apply electronic, automated processes to minimize operational staff time spent on routine, repetitive required functions.

Accordingly, these technologies are highly integrated with other TDDs that seek to maximize the use of automated plant condition monitoring and automated processes.

3.5.4 Key Insights

There are linkages and synergies between TDD O1 and other TDDs that involve 3-D plant modeling, central plant condition and configuration databases, remote monitoring and planning, and plantwide connectivity. Accordingly, staff reductions could be optimized more effectively if all of them are implemented in a coordinated fashion.

3.6 Outage Management

Outage Management was pre-worked by SME and TAG members prior to the meeting in which it was covered. It was discussed in the same level of detail as all other staffing areas. The TAG concluded that because of the extensive industry work already underway/completed in outage management, including optimization of staffing during outages, this plant staffing area was considered by the project in the context of how each TDD would apply to the outage scope and whether the TDD could be applied to reduce associated outage staffing levels.

Note: The scope and frequency of outages may be different for different SMR designs. Accordingly, the discussion below is based on the scope of a typical operating nuclear power plant outage. SMR vendors and Owner/Operators would need to evaluate applicability of each of these TDDs in light of how they would apply to individual designs.

Each of the TDDs listed in Table 3-6 identifies processes or capabilities that—once established in support of routine operations—provide the ability to plan and execute outages more effectively. Although other TDDs may provide functionality relevant to outage management, the ones listed in the table were judged by the project to provide the highest potential for reducing staff required during outages.

Table 3-6
Overview of TDD staff reduction potential for outage management

TDD No.	Title
C1	Automated Sampling and Analysis – Chemical
C2	Automated Sampling and Analysis – Radiological
C3	Chemical and Radiological Analysis Software Suite
RP3	Automated Personnel Monitoring and Dosimetry
RP4	Automated ALARA Job Reviews and RWP Generation
RP5	Automated Radiation Monitoring and Analysis
M1	Standardized Components
M2	Cross-Training of Maintenance Staff
M3	Connectivity
M4	Automated Electronic Mobile Work Management
M5	Design for Maintenance Effectiveness and Efficiency
E1	Engineering Tools
E2	Automated Plant Health Management System Assuring Plant and Equipment Reliability
O1	Intelligent Configuration Management Optimization
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures
T1	Use of Advanced, Technology-Based Training Methods
SC1	Supply Chain and Procurement Engineering Tools
WH1	Automated Parts Supply

3.7 Training

3.7.1 Staff Reduction Technologies

Potential staff reduction technologies identified for training are listed in Table 3-7.

Table 3-7
Data capture table: training

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	Description			
T1	Use of Advanced, Technology-Based Training Methods	H	L	A

3.7.2 Technologies Selected for TDDs

TDD T1 was selected for development of detailed information in a TDD, because it is projected to achieve high decreases of staff in operations, training, and other staff areas due to streamlined, automated methods for training delivery, increased training effectiveness, on-demand and remote training, and an increased ability to cross-train and use training personnel for other staff functions.

<u>T1 – Use of Advanced, Technology-Based Training Methods</u>
Utilize advanced training techniques (e.g., augmented and virtual reality, serious games, self-training and e-learning capabilities, mock ups, 3D Component Training aides) to reduce plant staff time and training resources required to achieve training objectives and to deliver training (e.g., physical simulator and instructor time). This includes reducing both the absolute time and the calendar duration required to achieve training.

3.7.3 Overarching Concepts

The TDD would be implemented by tailoring existing software and other delivery systems using advanced training techniques to specific SMR training requirements.

3.7.4 Key Insights

Application of this TDD will enable reducing both the absolute time and the calendar duration required to achieve training objectives.

3.8 Emergency Preparedness

3.8.1 Staff Reduction Technologies

Potential staff reduction technologies identified for emergency preparedness are listed in Table 3-8.

Table 3-8
Data capture table: emergency preparedness

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	Description			
EP1	Use of IPAWS Public Notification System for Emergency Communications	L	L	C
EP2	Remote and Alternate Facility Implementation	H	H	B

3.8.2 Technologies Selected for TDDs

Implementation of TDD EP1would allow use of an existing Federal Emergency Management Agency (FEMA)-maintained emergency notification system, obviating the need for a stand-alone system for each SMR plant, thereby minimizing multiple emergency systems, reducing the need for on-site equipment, optimizing interface requirements, and eliminating siren maintenance. Although this technology is expected to provide a relatively small reduction in staffing, these additional advantages were judged to provide sufficient benefit to SMR sites that further detailed consideration is appropriate.

TDD EP2 was selected for detailed TDD development because it would provide significant staff reductions with a relatively low development effort, using essentially available technology configured to the needs of a virtual ERO facility. Additional benefits in staff availability and safety during certain emergency events could also accrue. Reduced on-site and report-to-site staffing requirements would result.

Descriptions of the selected technologies and design details follow.

<u>EP1 – Use of IPAWS Public Notification System for Emergency Communications</u>
Public notification technology has developed rapidly in the last few decades and the opportunity to leverage public services to transition away from owner-provided alerting systems is now possible. While current regulatory guidance may seem to prevent this, clear demonstration of the effectiveness of the existing and growing government-mandated alerting systems to have a high efficacy for nuclear evacuation alerts would allow their exclusive use for EPZ evacuation response. The FEMA sponsored IPAWS system (see conceptual diagram in TDD) provides multi-modal alerts to a variety of channels that include localization capabilities. Of particular interest is the Wireless Alert System (formerly CMAS) that provides localized alerting via mobile devices.

<u>EP2 – Remote and Alternate Facility Implementation</u>
Use modern communications technology to create “virtual” ERO (Emergency Response Operation) facilities that ease the burden of facility manning, design, construction, and maintenance. Using current and planned commercial LTE (Long Term Evolution) services or internet service-provider networks, ERO members would join the virtual alternate ERO facility from their homes, remote work location, or ad-hoc sheltering location. This can be achieved by

the use of private, secure virtual networks (MPLS, or carrier custom implementations). A virtual alternate ERO would reduce the security manning and technology support requirements of the alternate ERO facility. It would provide enhanced employee safety during events that prevent the use of the normal ERO facility such as hostile action or severe natural event.

3.8.3 Overarching Concepts

Both emergency preparedness TDDs would leverage existing technologies and systems to reduce operating burden associated with maintaining EP facilities and capabilities.

3.8.4 Key Insights

Both EP TDDs would leverage existing technologies and capabilities to reduce EP staff burden and to make emergency response operations more efficient and effective. A key component of these efficiencies will be the reduction in staff time required in activities to train and prepare for emergency event. For example, for EP1, testing and maintenance of notification equipment is the responsibility of alert disseminators, not the plant owner. Implementation of TDDs EP1 and EP2 will need agreement by the U.S. Nuclear Regulatory Commission (NRC) while requiring support from Department of Homeland Security/Federal Emergency Management Agency (DHS/FEMA), as well as possible concurrence from state and local emergency management agencies.

The benefit and effectiveness of EP2 is amplified as the ability of off-site fleet wide support capability grows.

3.9 Warehousing and Supply Chain

3.9.1 Staff Reduction Technologies

Potential staff reduction technologies identified for supply chain management and warehousing are listed in Table 3-9.

Table 3-9
Data capture table: warehousing and supply chain

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	Description			
SC1	Supply Chain and Procurement Engineering Tools	H	L	A
WH1	Automated Parts Supply	H	L	A

3.9.2 Technologies Selected for TDDs

Both TDDs were selected for more detailed development because they could provide significant staff reductions with relatively small development effort. Also, as noted below, the two TDDs involve significant synergies and should be implemented in parallel.

Descriptions of the selected technologies and design details follow.

<u>SC1 – Supply Chain and Procurement Engineering Tools</u>
Establish an "above average" Enterprise Asset Management system that is fully populated, as a minimum, with the supply chain related data in Attachment 1 to TDD-SC1 prior to initial plant operations.

Ideally, stocking levels and reorder parameters will be established in advance. Demand for replacement items is automated. When a task to be worked is scheduled, the system will check to see if the necessary quantity will be available on the start date. If not, a reorder notice will be generated. Pre-negotiated agreements and pricing would further reduce the need for manual involvement in the purchasing process. The vast majority of reorders will be awarded to the NSSS or their designated source of supply. This will facilitate batch processing that will decrease the number of purchase order, invoice, and accounts payable transactions necessary to support procurement.

<u>WH1 – Automated Parts Supply</u>
Technology and design aspects of selected warehouse locations should be fully compatible with maintenance connectivity TDD M3. This should include maximum automation of parts requests, warehouse acknowledgement, part location and identification, access to and movement of the part, verification and release from warehouse, part return when needed. This is enabled by TDD SC1.

3.9.3 Overarching Concepts

These TDDs are intended to provide a high degree of automation of the processes for identifying, procuring, storing, and putting into service parts and equipment used in maintaining and operating the plant. Parallel implementation of these TDDs is recommended.

3.9.4 Key Insights

TDD SC1 functionality is closely related to that of TDD E1, Engineering Tools. Consideration should be given by users to joint deployment of these two TDDs to take advantage of development efficiencies and to optimize staff reductions achieved. Assembly of data to populate the EAM system must begin with initial procurement of engineered equipment, so that the system is kept current throughout construction and operation of the plant.

Development of TDD WH1 development and implementation should be integrated with efforts to implement TDD M3, Connectivity; also, this TDD is enabled by TDD SC1.

As noted in Section 2.4, feed forward of design details and OEM information into plant operations is critical to the success of these capabilities.

3.10 Security

3.10.1 Staff Reduction Technologies

Potential staff reduction technologies identified for security are listed in Table 3-10.

Table 3-10
Data capture table: security

Staff Reduction Technology		Net Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
No.	**Description**			
S1	Target Set Reduction	H	L	A
S2	Security Barrier Location and Effectiveness	H	H	B
S3	Design Vulnerability Reduction	H	L	A

3.10.2 Technologies Selected for TDDs

All three TDDs were selected for more detailed development because they could provide significant staff reductions, though with potentially significant development effort. As noted in Subsections 3.10.3 and 3.10.4, these TDDs address aspects of plant design that are considered "safeguards" information; accordingly, security staff optimization through TDD implementation will have to be developed by plant designers in accordance with applicable NRC information classification requirements.

Descriptions of the selected technologies and design details follow.

S1 – Target Set Reduction
Use design options that reduce the number of potential targets in the plant layout. The reduction of target sets can be accomplished by implementing the following methods during the initial plant design and physical layout:

- Use of passive methods for ultimate core cooling.
- Design features that cannot be activated or deactivated that result in inoperable core cooling conditions.
- Utilize core cooling technologies or defensive barrier technologies that rely on inherent material properties and do not require external power to activate.
- Location of targets vs. necessary reaction time needs should be considered (i.e., reduce number of ready rooms).

S2 – Security Barrier Location and Effectiveness
Use barrier designs that provide enhanced security and superior effectiveness. Security barrier locations can be designed into the plant layout as follows:

- Use of passive intrusion detection
- Use of fortified passive barrier technology
- Use of personnel identification technology to limit access only to authorized personnel
- Use of multiple and diverse physical barriers to delay unauthorized access attempts

S3 – Design Vulnerability Reduction
Reduce vulnerability to radiological sabotage provided by engineered protection systems while reducing or eliminating reliance on human actions. The functionality must provide high assurance that activities involving special nuclear and high-level waste material are not inimical to common defense and security, and do not constitute an unreasonable risk to the public health and safety.

The reduced vulnerability can be accomplished by implementing the following methods during the plant design and physical layout:

- Use of passive methods for ultimate cooling
- Reduced access points to waste nuclear material
- Remote or automated handling of waste nuclear material
- Automated handling of waste nuclear material
- Consolidate and physically monitor and protect remaining vulnerability points

3.10.3 Overarching Concepts

The SMR security staffing levels are not public information and will be "safeguards'" information when they are known. However, given that security staffing is a major nuclear plant staffing component and reduced target sets, security barrier optimization, and design vulnerability reductions will reduce security staff requirements, potentially significant staff reductions are possible.

3.10.4 Key Insights

An NEI plant SMR security white paper has been prepared for NRC review. This white paper proposes that due to lower source term for SMR the approach to SMR plant security be changed from "detect, assess, engage and neutralize" to "detect, assess and communicate," using a consequence-based framework for security plan evaluation. Acceptance and implementation of this approach by the NRC in concert with the technologies identified in these TDDs is critical to success of SMR security staff reduction.

These TDDs were developed by the NEI working group on SMR security. A TAG member of this SMR Staffing Optimization Project was also a member of the NEI group. This co-membership allowed these TDDs to be developed without compromising security details.

4
TDD CONTENT APPLICATION BY INDIVIDUAL USERS

Subsections 4.1 through 4.4 of this section call out the TDDs that can at this time be directly used by or impacted by the user highlighted in the respective subsection. Subsection 4.5 provides perspective on the applicability and level of effort involved if these TDDs were implemented in a current-generation plant.

The essential content of each TDD is found in the Technology and Design Detail description (see Appendix C for individual TDDs). This captures the central idea being communicated. Design, Project Management, and Operational assumptions, where present, are included are to highlight known conditions that are important to the ultimate success of the application of the TDD.

Most TDDs have Development Needs listed.

- The Enhanced needs improve the benefits of the TDD but do not preclude design inclusion of the TDD using existing technologies.
- The Essential needs are considered to be those needs that should be resolved prior to full implementation of the TDD.

Although this report recommends that industry R&D groups take action to satisfy these needs, any SMR design group can move ahead unilaterally to satisfy these needs to the extent necessary for inclusion of the TDD into their design. For purposes of this report, it is assumed that Enhanced needs can be readily resolved by SMR design teams allowing application of the TDD. Although achievable by SMR design teams and component vendors, it is assumed that industry groups will take the lead in resolving Essential needs (see Section 4.3).

Listed Regulatory items follow the same logic as Enhanced Development needs. SMR design teams can accomplish these through their interaction with regulators. However, for this report, we are calling these out for action by nuclear industry regulatory interface groups.

4.1 SMR Designers and EPC Groups

TDDs in this report are intended to be an asset to SMR designers and the Engineering, Procurement, and Construction (EPC) consortiums that may propose project plans for power generation projects. The TDDs represent the considered insight of experienced nuclear power professionals with varied backgrounds from many organizations (see listings in the acknowledgements in the front of this report); accordingly, the TDDs are considered viable. It is the intent of these individuals and this project that these TDDs allow deployment of SMR plants that not only operate more effectively but also achieve containment of the ongoing staffing costs of the plants. SMR designs that include demonstrated features to improve their operations and contain their ongoing operations and maintenance (O&M) costs are more likely to be purchased by utilities and other power generators.

Designers considering these TDDs should make a distinction between the hardware "backbones" to enable these TDDs and the software structures that will allow them to be fully implemented. Both hardware and software structures are most effectively implemented during the design stage of plant development. Post-design incorporation will make deployment less effective and/or more expensive and will compromise the ability to take advantage of the fleet deployment advantages of the TDDs.

Where practical, self-monitoring and communications-enabled components and equipment should be pursued in the design even if the enabling IT platform (software and hardware) is yet to be fully developed.

Table 4-1
TDDs ready for use by SMR design teams

TDD Number	TDD Title	Notable Limitations
C1	Automated Sampling and Analysis – Chemical	Some applications limited – see development needs in TDD
C2	Automated Sampling and Analysis – Radiological	Some applications limited – see development needs in TDD
RP3	Automated Personnel Monitoring and Dosimetry	None of note – some functionality may be pending development
RP5	Automated Radiation Monitoring and Analysis	None of note – some functionality may be pending development
M1	Standardized Components	None
M2	Cross-Training of Maintenance Staff	None of note in the TDD – see regulatory in TDD for needed reviews
M3	Connectivity	None of note in the TDD Regulatory attention will be needed – see regulatory in TDD
M4	Automated Electronic Mobile Work Management	None of note in the TDD Regulatory attention will be needed – see regulatory in TDD
M5	Design for Maintenance Effectiveness and Efficiency	None of note in the TDD
E1	Engineering Tools	None of note in the TDD
E2	Automated Plant Health Management System Assuring Plant and Equipment Reliability	None of note in the TDD

Table 4-1 (continued)
TDDs ready for use by SMR design teams

TDD Number	TDD Title	Notable Limitations
E3	Program Engineering Automation	Minor limitations – see development needs in TDD
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures	Some applications limited – see development needs in TDD
T1	Use of Advanced, Technology-Based Training Methods	None of note in the TDD
EP1	Use of IPAWS Public Notification System for Emergency Communications	None of note in the TDD – proof of application may be needed
SC1	Supply Chain and Procurement Engineering Tools	None
WH1	Automated Parts Supply	None
S1	Target Set Reduction	Subject to security details
S2	Security Barrier Location and Effectiveness	Subject to security details
S3	Design Vulnerability Reduction	Subject to security details

As discussed in Section 2.2, the designers of SMR plants and the EPC consortiums that are primary users of this report should:

- Seriously consider each TDD listed in Table 4-1 for incorporation into their SMR basic conceptual approach. The remaining TDDs should be reviewed for possible action.
- Incorporate the TDD statements and supporting assumptions (design, construction, and operational) into the necessary design basis documents that guide and document their plant design. Limitations due to pending development should be noted.
- Translate these design basis document requirements into the supporting procurement specifications and construction/turnover instructions for the project. Where practical, provide for/allow later incorporation of final resolution of pending development needs.

4.2 Potential Owner/Operators of SMR Plants

The TDDs in this report are intended for use by the potential Owner/Operators of SMR plants. Potential Owner/Operators can use these insights as they consider locations, numbers, and feasibility of a fleet of SMR. Owner/Operators can influence the design and operation of any SMR they may purchase. They do this by providing guidance (expectations) to potential vendors of SMR during preliminary discussions. They do this by incorporating technical content into their bid and purchasing documents. All of the TDDs in this report support these Owner/Operator actions.

The TDDs in this report were identified and detailed by professionals with first-hand design, construction, and operational experience with nuclear power plants. This broad base of industry experience means that all of the TDD concepts captured are achievable. The TDDs were conceived with a sound understanding of the capabilities of component vendors, SMR designers, EPC project managers, and worldwide Research and Development staffs. In other words, the TDDs in this report are “doable.” Given that they are achievable, each of the TDDs should receive strong consideration by Owner/Operators for inclusion in the requirements of their SMR plant.

For those TDDs with development needs, the Owner/Operators should work with industry R&D groups and potential SMR vendors to achieve as much of the developmental work prior to their plant purchase as is reasonable. The same is true for pending regulatory needs.

As discussed in Section 2.2, Owner/Operators of SMR plants are intended users of this report. They should:

- Seriously consider all TDDs in this report for inclusion in the SMR plant they are considering for purchase.
- Advise potential SMR bidders of their desire to have these capabilities in any project plan proposed.
- Incorporate desired TDD capabilities and supporting assumptions into project SMR request for quotation (RFQ) technical requirements.
- Incorporate desired TDD capabilities and supporting assumptions into selected SMR vendor contractual technical requirements.
- Assure that planned and actual plant organizational structures and functions maximize use of the incorporated TDD capabilities and sustain the effectiveness of the capabilities.

4.3 Research and Development Groups

The TDDs in this report are intended for use by worldwide Research and Development (R&D) groups that support the industry. Among these groups are the U.S. Department of Energy (DOE) Office of Nuclear Energy and the Electric Power Research Institute (EPRI) Nuclear Sector. Many other international R&D groups support their countries and regions. Individual component, SMR, and software vendors have R&D groups that can and should use these TDDs.

The Development Needs portions of the TDDs were produced for the benefit of R&D groups. The statements of need captured in the TDDs were written by professionals experienced in using R&D processes to achieve needed practical results. Therefore, the needs stated in the TDDs are considered to be well within the ability of typical R&D managers and technical personnel.

Most TDDs have Development Needs listed. The Enhanced needs improve the benefits of the TDD but do not preclude design inclusion of the TDD using existing technologies. The Essential needs are considered to be those needs that should be resolved prior to full implementation of the TDD. R&D groups are expected to eliminate as many of the development needs as possible, allowing maximum use of the TDD concept by the SMR design and Owner/Operator communities.

Table 4-2 identifies the TDDs that have development needs and states the classification of those needs (Enhanced and/or Essential).

As seen in the data capture tables presented in Section 3 and as prioritized in Table 5-1, the TAG in session estimated the level of full development need for a TDD to be above or below $5M. In Table 4-2, the project has further refined the TAG's estimate to characterize the expected level of effort needed for the two classifications of development needs (Enhanced and Essential). The level of effort is based on experience with similar R&D projects.

Table 4-2 shows the estimated effort for each of the development subparts individually (Enhanced, Essential). The full development of the TDD would be the combination of the two.

Table 4-2
TDDs needing R&D attention, action, and initiation

TDD Number	TDD Title	Enhanced Need	Effort	Essential Need	Effort
C1	Automated Sampling and Analysis – Chemical	Yes	>$1M<$5M	Yes	>$1M<$5M
C2	Automated Sampling and Analysis – Radiological	Yes	>$1M<$5M	Yes	<$1M
C3	Chemical and Radiological Analysis Software Suite	No		Yes	>$1M<$5M
RP3	Automated Personnel Monitoring and Dosimetry	No		Yes	<$1M
RP4	Automated ALARA Job Reviews and RWP Generation	Yes	>$1M<$5M	Yes	>$1M<$5M
RP5	Automated Radiation Monitoring and Analysis	Yes	<$1M	Yes	<$1M
RP9	Automated Public Dose Assessment for EP	No		Yes	>$1M<$5M
M2	Cross-Training of Maintenance Staff**	No		Yes	>$5M

Table 4-2 (continued)
TDDs needing R&D attention, action, and initiation

TDD Number	TDD Title	Enhanced Need	Effort	Essential Need	Effort
M3	Connectivity	Yes	<$1M	No	
E1	Engineering Tools	Yes	>$5M	No	
E2	Automated Plant Health Management System Assuring Plant and Equipment Reliability	Yes	>$1M<$5M	No	
E3	Program Engineering Automation	Yes	<$1M	No	
O1	Intelligent Configuration Management Optimization	Yes	<$1M	Yes	<$1M
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures	Yes	<$1M	Yes	>$5M
T1	Use of Advanced, Technology-Based Training Methods	Yes	<$1M	No	
EP1	Use of IPAWS Public Notification System for Emergency Communications	Yes	<$1M	No	
EP2	Remote and Alternate Facility Implementation	Yes	>$1M<$5M	Yes	>$1M<$5M
SC1	Supply Chain and Procurement Engineering Tools	Yes	<$1M	No	
S1	Target Set Reduction	Yes	<$1M	Yes	<$1M
S2	Security Barrier Location and Effectiveness	Yes	>$5M	No	

** Effort estimate is for all plant functions that could be cross-trained.

As discussed in Section 2.2, R&D organizations—specifically the U.S. Department of Energy, EPRI, and applicable international organizations—are intended primary users of this report. They should:

- Review TDDs called out in Table 4-2 to understand the Enhanced and Essential development tasks that have been identified.
- Understand and prioritize development needs. Coordinate with SMR designers to identify pressing needs and assure the designers are engaged with development efforts.
- Initiate specific projects to supply the information/capability needed to allow the TDDs to be fully implemented by SMR design organizations.
- Inform the SMR design community of the existence of these projects and provide them the results of the projects for their use.

4.4 Industry Regulatory and Policy Groups

Industry regulatory and policy groups play an enabling role allowing implementation of the TDD concepts. Accordingly, they are users of the TDDs. The regulatory and policy groups of note for the U.S. nuclear industry are the Nuclear Energy Institute (NEI) and the Institute of Nuclear Power Operations (INPO). Frequently their role is to work with the industry to establish a consistent or standard approach on a given topic. NEI has the added responsibility of being the industry lead in resolution of items needing agreement with federal agencies such as the Nuclear Regulatory Commission (NRC) staff. Other countries have similar regulatory and policy groups that support their nuclear industries, such as the World Association of Nuclear Operators (WANO), the International Atomic Energy Agency (IAEA), and other, country-specific groups. To the extent that other countries have adopted policies similar to those of the U.S. NRC and INPO, then the regulatory comments by the project in the TDDs should be applicable.

The project assumed that the normal industry practice of SMR vendors/designers resolving issues through required reviews and licensing actions with the NRC would be ongoing. Items called out for regulatory and policy attention in the TDDs are those that the project believed were important for the success of the full application of the TDD.

The TDDs were developed by professionals experienced with the roles of NEI and INPO. This allowed the project to call out topics possibly needing regulatory and/or policy attention. However, given the complexity of regulations and industry policy, it is recommended that NEI and INPO personnel review all of the TDDs to identify actions needed but not called out by the project. Also, the exact nature of the required regulatory and/or policy effort may be different than envisioned by the project and documented in the TDDs.

Table 4-3 displays those TDDs the project noted as needing NEI and/or INPO attention and action.

Table 4-3
TDDs needing attention from NEI and/or INPO

TDD Number	TDD Title	NEI	INPO
C1	Automated Sampling and Analysis – Chemical	Yes	
RP3	Automated Personnel Monitoring and Dosimetry	Yes	
RP5	Automated Radiation Monitoring and Analysis	Yes	
RP9	Automated Public Dose Assessment for EP	Yes	
M2	Cross-Training of Maintenance Staff**	Yes	Yes
M3	Connectivity	Yes	
M4	Automated Electronic Mobile Work Management	Yes	
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures	Yes	
EP1	Use of IPAWS Public Notification System for Emergency Communications	Yes	
EP2	Remote and Alternate Facility Implementation	Yes	
S1	Target Set Reduction	Yes	
S2	Security Barrier Location and Effectiveness	Yes	
S3	Design Vulnerability Reduction	Yes	

** It is noted that the concept and benefits of cross-training were discussed in and are achievable in many plant functions. The project provided a detailed documentation of cross-training in TDD M2 and to a lesser degree in TDD T1 (Training). As called out in Section 2.4, cross-training in every plant function should be the expectation, not the exception.

As discussed in Section 2.2, industry groups such as NEI, INPO, and similar international groups are intended users of this report. They should:

- Review the TDDs called out in Table 4-3 as needing regulatory and policy action to allow or enable use of the TDD concept. A refinement of the proposed regulatory and/or policy action may be needed.
- Consider regulatory and policy initiatives already underway and include the TDD needs in these efforts.
- Create new regulatory and policy initiatives to address TDD needs if they do not fit appropriately with other work underway.
- Perform a general review of all TDDs to identify needed regulatory and/or policy actions that were not identified by the project.

4.5 Current Fleet of Operating Power Reactors, Long-Term Operations Plants, and ALWR

Because the SMR Staffing Optimization project limited its efforts to light water reactor technologies, all TDDs identified are applicable to current and future generations of large nuclear plants. However, since some TDDs must be achieved or enabled by the plant basic design, not all of the identified TDDs can be applied to currently operating limited-life plants. Plants that plan long-term operations can apply a larger number of the TDDs. The evolving fleet of ALWR plants can implement almost all of the TDDs.

The project looked at each TDD to judge practicality of application. The following criteria were used:

- The TTD concept is achievable in plants with "reasonable effort," with *reasonable effort* being taken to mean that it is not outside of the ability of a typical plant to accomplish all or a subset of the TDD. (Yes)
- The TDD concept is technically achievable in a plant, but the cost to accomplish the TDD plus the disruption to the plant may be excessive. Limited application and benefit are possible. (Limited)
- The TDD concept, although within the technology of the plant, is not practical to pursue. (No)

Table 4-4 ranks all TDDs based on their application feasibility.

Table 4-4
TDD current fleet feasibility

TDD Number	TDD Title	Staffing Impact	Limited License Plants	Long-Term Operation Plants	New ALWRs
M2	Cross-Training of Maintenance Staff	H	Yes	Yes	Yes
E2	Automated Plant Health Management System Assuring Plant and Equipment Reliability	H	Yes	Yes	Yes
T1	Use of Advanced, Technology-Based Training Methods	H	Yes	Yes	Yes
EP1	Use of IPAWS Public Notification System for Emergency Communications	L	Yes	Yes	Yes
C1	Automated Sampling and Analysis – Chemical	H	Limited	Limited	Yes
C2	Automated Sampling and Analysis – Radiological	L	Limited	Limited	Yes

Table 4-4 (continued)
TDD current fleet feasibility

TDD Number	TDD Title	Staffing Impact	Limited License Plants	Long-Term Operation Plants	New ALWRs
C3	Chemical and Radiological Analysis Software Suite	L	Limited	Limited	Yes
RP3	Automated Personnel Monitoring and Dosimetry	H	Limited	Yes	Yes
RP4	Automated ALARA Job Reviews and RWP Generation	H	Limited	Yes	Yes
RP5	Automated Radiation Monitoring and Analysis	H	Limited	Yes	Yes
RP9	Automated Public Dose Assessment for EP	H	Limited	Limited	Yes
M3	Connectivity	H	Limited	Yes	Yes
M4	Automated Electronic Mobile Work Management	H	Limited	Yes	Yes
E3	Program Engineering Automation	H	Limited	Limited	Yes
SC1	Supply Chain and Procurement Engineering Tools	H	Limited	Yes	Yes
WH1	Automated Parts Supply	H	Limited	Yes	Yes
M1	Standardized Components	H	No	No	Yes
M5	Design for Maintenance Effectiveness and Efficiency	L	No	Limited	Yes
E1	Engineering Tools	H	No	Limited	Yes
O1	Intelligent Configuration Management Optimization	H	No	No	Yes
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures	H	No	No	Yes
EP2	Remote and Alternate Facility Implementation	H	No	Limited	Yes

Table 4-4 (continued)
TDD current fleet feasibility

TDD Number	TDD Title	Staffing Impact	Limited License Plants	Long-Term Operation Plants	New ALWRs
S1	Target Set Reduction	H	No	No	Limited
S2	Security Barrier Location and Effectiveness	H	No	Limited	Yes
S3	Design Vulnerability Reduction	H	No	No	Limited

5
TDD PRIORITIZATION AND COMMON INFRASTRUCTURE

5.1 TDD Prioritization

A prioritization of the rank of the 25 TDDs detailed in Appendix C is provided in Table 5-1. The rank of each TDD was established using the matrix displayed in Figure 2-2.

- Of the fifteen TDDs ranked “A” (>5 FTE net impact), twelve were judged to have a development cost less than $1M.
  - As discussed in last item of the list in Section 2.4, a real-time interactive plant data-centric configuration management process based on a current three-dimensional plant model is assumed and is necessary for nine of these. (See the expanded discussion in Section 5.2.1.)
- Six of the TDDs were ranked “B” (>5 FTE net impact with development cost >$5M). These topics have the potential for significant staffing impact but carry a higher cost to be made fully design ready.
- Of the four TTDs ranked “C” (<5 FTE net impact), two (C2 and C3) were judged to have development cost above $1M.

Users of this table are cautioned that many of these TDDs have related and synergistic compounding value. Consider the holistic development and use of related TDDs as the desired approach.

Appendix E contains a listing of each of the TDDs with an assigned EPRI Technical Readiness Level. Table E-1 communicates the project understanding of the maturity of the associated technologies and/or design considerations for each.

Table 5-1
TDD prioritization

Staff Reduction Technology		Net Staffing Impact H/L	Effort to Develop H/L	Rank (A/B/C/D)
TDD No.	**Title**			
E3	Program Engineering Automation	H	L	A
M1	Standardized Components	H	L	A
M3	Connectivity	H	L	A
M4	Automated Electronic Mobile Work Management	H	L	A
O1	Intelligent Configuration Management Optimization	H	L	A
RP3	Automated Personnel Monitoring and Dosimetry	H	L	A
RP5	Automated Radiation Monitoring and Analysis	H	L	A
S1	Target Set Reduction	H	L	A
S3	Design Vulnerability Reduction	H	L	A
SC1	Supply Chain and Procurement Engineering Tools	H	L	A
T1	Use of Advanced, Technology-Based Training Methods	H	L	A
WH1	Automated Parts Supply	H	L	A
E2	Automated Plant Health Management System Assuring Plant and Equipment Reliability	H	L+	A
RP4	Automated ALARA Job Reviews and RWP Generation	H	L+	A
RP9	Automated Public Dose Assessment for EP	H	L+	A
C1	Automated Sampling and Analysis – Chemical	H	H	B
E1	Engineering Tools	H	H	B
EP2	Remote and Alternate Facility Implementation	H	H	B
M2	Cross-Training of Maintenance Staff	H	H	B
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures	H	H	B
S2	Security Barrier Location and Effectiveness	H	H	B
C2	Automated Sampling and Analysis – Radiological	L	L	C
C3	Chemical and Radiological Analysis Software Suite	L	L	C
EP1	Use of IPAWS Public Notification System for Emergency Communications	L	L	C
M5	Design for Maintenance Effectiveness and Efficiency	L	L	C

5.2 Common Infrastructure Platforms

In examining the TDD set, several common functions and infrastructure platforms were identified that enable or support implementation of multiple TDDs and their associated staff optimization benefits. These common elements are the following:

1. Data-centric plant information model (PIM) and configuration management (CM) system (e.g., system and component condition database, plant configuration and status database, 3-D plant model, training/qualification database).
2. Communications/connectivity (e.g., in-plant wireless and off-site management channels, internal positioning system [IPS]). Cyber security is an additional consideration of system design requirements for this element.
3. Automated processes and reporting (e.g., work planning, RWP generation, dose calculations, plant health monitoring).
4. Automated monitoring, analysis, and reporting (e.g., chemical and radiological parameters, component and system status and condition).
5. Automated procedures and training.

An overview of these common elements as they apply across the TDD set is provided in Figure 5-1. (Security TDDs are not included in the figure.)

Infrastructure Platform	C1	C2	C3	RP3	RP4	RP5	RP9	E1	E2	E3	M1	M2	M3	M4	M5	O1	O2	T1	EP1	EP2	SC1	WH1
Configuration-controlled plant status databases and tools (including 3-D plant model, engineering tool set, and component status)				U				U	U				P	U		P		U			U	U
Communications/ connectivity (in-plant wireless and off-site management, internal positioning system); this would include the cyber-security concerns	U	U		U	U	U	U		U	U			P	U		U	U			U		U
Automated processes and reporting (work planning, RWP generation, dose calculations, plant health monitoring)				P	P		P		P	P			P	P			P					U
Automated monitoring, analysis, and reporting (chemical and radiological parameters, component and system status)	P	P	P	P	U	P	P		P	P												
Automated procedures and training												U		U			P	P				

P	Provides Infrastructure	U	Utilizes Infrastructure

Figure 5-1
Overview of common functions and infrastructure, by TDD

The project determined that there are significant synergies that could be realized by developing these common functions and infrastructure in a coordinated fashion, taking into account needs of the relevant TDDs. Benefits from approaching staff reduction technologies through these synergies (as compared to "one-off" TDD implementation) include the following:

- Increased reliability and improved communications/interfaces realized by using common hardware and software for multiple functions
- Potential for increased automation and staff reductions
- Reduction in development time and cost
- Improved configuration control as systems and processes mature
- Improved ability for personnel to perform tasks across multiple plant functions (everyone talks the same language)

To assist users (see Section 4) in capitalizing on the potential synergies in development and deployment of multiple TDDs, the scope of these common elements—as reflected in the multiple individual TDDs to which they apply—is cataloged in the following subsections. Section 5.2.6 provides a discussion on how the common function and infrastructure elements could be combined into an overall SMR plant digital backbone to achieve even more effective development and use of the TDDs.

When attempting to achieve the levels of data, analysis, reporting, and process integration described, it is easy to get lost in the technical and software details. The project team strongly recommends that designers and appliers of these capabilities continually return to the desired end uses and assure that these uses are being and will be achieved.

5.2.1 Plant Information Model (PIM) and Data-Centric Configuration Management (CM) System

This functionality provides the foundational infrastructure underpinning for many of the TDDs, as noted in Table 5-2. Components of this include highly accurate three-dimensional plant models and databases (system, component, and training) that are automatically maintained, are updated in real time, reflect actual plant status, and are accessible to all plant physical spaces.

This functional element provides the underpinning data-centric plant condition infrastructure that supports TDDs identified in Table 5-2.

Table 5-2
TDDs supported by data-centric PIM and CM systems

TDD		Scope Element
No.	**Title**	
RP3	Automated Personnel Monitoring and Dosimetry	Plant 3-D model
RP4	Automated ALARA Job Reviews and RWP Generation	Plant 3-D model
RP5	Automated Radiation Monitoring and Analysis	Plant 3-D model
E1	Engineering Tools	Plant 3-D model
E2	Automated Plant Health Management System Assuring Plant and Equipment Reliability	System and component condition database
M3	Connectivity	Plant 3-D model System and component condition database Training/qualification database
M4	Automated Electronic Mobile Work Management	Plant 3-D model System and component condition database Plant configuration and status database Training/qualification database
O1	Intelligent Configuration Management Optimization	Plant 3-D model Decision-quality
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures	
T1	Use of Advanced, Technology-Based Training Methods	Plant 3-D model
SC1	Supply Chain and Procurement Engineering Tools	System and component condition database Plant configuration and status database
WH1	Automated Parts Supply	System and component condition database Plant configuration and status database

Although this foundational infrastructure does not currently exist in its entirety, considerable research and development has been already been conducted by EPRI and industry that drives toward full deployment of this functionality; a list of references providing detailed work that supports this underpinning infrastructure is contained in Figure 5-2.

1. Data-Centric Configuration Management for Efficiency and Cost Reduction: An Economic Model for Implementation (2014), Product ID: 3002003126. This study identifies, in a probabilistic return on investment model, the profound cost savings in a well-designed data-centric configuration management information system (CMIS).
2. New Nuclear Power Plant Information Handover Guide (Revision 1) (March 2016 publication). This updated version provides the lessons learned by the current new plants with a discussion on the inefficiencies and added cost experienced by not defining a detailed information turnover plan early with the Architect-Engineer.
3. Elements of Pre-Operational and Operational Configuration Management for a New Nuclear Facility (2013), Product ID: 1022684. This study describes a framework for a modern CMIS. The study defined the need for a PIM to obviate the need for each new build to develop its own CMIS. Having a different data structure for each plant in a standard NSSS design fleet hinders the ability to exchange and trend data across the fleet.
4. Advanced Nuclear Technology: Impact of EPRI Pre-Operational and Operational Configuration Management Report (1022684) on the Nuclear Industry (2013), Product ID: 3002000221. This study examines the activities and events that have transpired since the publication of EPRI Report 1022684 and presents a recommended path forward.
5. Program on Technology Innovation: Staff Optimization Scoping Study for New Nuclear Power Plants (2005), Product ID: 1011717.
6. Development of an Evaluation and Acceptance Methodology for Commercial Two- and Three-Dimensional Plant Modeling Software (2013), Product ID: 3002000272. This study investigated methods to certify 2-D and 3-D modeling software to meet 10 CFR 50 quality requirements. To achieve the goal of a fully connected 3-D model with analytical tools such as piping stress calculations, electrical load calculations, and heat load calculations, the 3-D model software must meet a higher standard than current practice.
7. Guideline on Configuration Management for Digital Instrumentation and Control Equipment and Systems (2011), Product ID: 1022991. This guideline provides focused guidance for implementing configuration management for modern digital I&C equipment and systems.

Figure 5-2
R&D supporting plant information model and data-centric configuration management

Additional development will be required to provide the full functionality identified in these TDDs, including:

- Development of a standard plant information model as the foundational interoperability infrastructure to seamlessly and efficiently facilitate information exchange and trending across the SMR plant life cycle. The PIM would provide the common language interoperability backbone for all the capabilities in Table 5-2, with a standard naming convention and relationship framework for documents, equipment, and other plant objects and the supporting properties.
- Such a PIM would provide:
  - A data-centric framework to model the plant life cycle to capture and manage information from conceptual design, licensing, design, procurement, installation, and operations
  - A design knowledge-centric platform to capture and preserve knowledge of design assumptions and decisions
  - A common language framework to seamlessly exchange information in an understandable, logical, traceable, reproducible, and manageable way between owner and contractors, and among a fleet of standard designs
  - A named relationship traceability framework to navigate and quickly find key related documents, requirements, and commitments to support engineering, operations, and maintenance activities as well as other plant activities
  - A semantically organized framework for handover/turnover representation of documents and data
  - A documents/data structured object taxonomy for interconnection with the 3-D model that can be leveraged by plantwide real-time processes
  - The interoperability single source of truth framework for quality, verified, change-controlled data needed to support and defend the design basis and plant processes and programs
  - The interchange of on-line real-time data among plant users and off-site support
  - The foundational interoperability infrastructure for electronic processes to streamline change control and decision making
- Key industry development steps:
  - Develop common language framework. Leverage, use, adopt, or harmonize with internationally accepted standards and other industry group initiatives where it is practical and makes sense to do so.
  - Develop the object model structures with minimum property sets. The previous EPRI PIM Initiative has already developed well-defined equipment objects and document objects. The following remain to be developed:
    - Location objects
    - Requirements objects

    - Procured (manufacture/model) objects
    - Installed objects
    - Organization roles objects
    - Program objects
    - Object property sets for object maturity and property inheritance
    - Drill-down on the property sets for each object to expand the life cycle
  - Develop traceability interconnect objects framework defining the named relationships and specific relationship rules between objects in the object model structures.
  - Document the model in a detailed data dictionary and develop an implementation plan.
  - Create XML structure for the PIM model and develop an online PIM demonstration model.
  - Create a semantically organized framework for exchange and handover/turnover representation of documents and data that can be downloaded from the online PIM demonstration model in multiple consumable outputs: XML, UML, spreadsheet, Word document.

There has been considerable discussion and preliminary work done to develop this functionality, including scoping of new build configuration management (including information turnover, plant information model), identifying of data-centric configuration management information system benefits, and developing a framework on which these concepts can be built to their full capabilities. Expertise and experience in these previous studies can be brought to bear in bringing this functionality to full capability.

SME currently involved with industry activities related to PIM estimate that a path forward for PIM for SMR can provide usable results within 12 months. Phased creation and release of needed PIM support content and capabilities can follow supporting the as-needed schedules for SMR project design and completion.

As noted in Section 2.4:

- **The integrity of the configuration management processes and content must be of the highest order.**
- **Recovery processes must be in place to minimize (limit) the impact to the project and/or the plant when errors in the configuration management processes and content are identified.**

5.2.2 Communications/Connectivity

Internal plantwide connectivity and communications would enable access by plant staff to all elements of the plant digital systems (non-control), processes, and databases at any location on site. External communications/connectivity would allow access by off-site personnel as necessary to perform fleet or remote plant technical and management tasks. With regard to specific TDDs, internal connectivity would enable staff to access all elements of the following staff optimization functions: remote monitoring, analysis, and logging of equipment and variables (C1, C2, RP3, RP4, E2, E3, O2, EP2, WH1); real-time decision-quality interface between equipment, equipment database, and staff (M3, M4, O1); and internal position system reporting for staff (RP3).

External monitoring and management communications enables the following staff optimization functions: centralized, off-site remote monitoring, analysis, and logging (C1, RP5, RP9, M3, M4) and automated satisfaction of program reporting requirements (E2, E3).

The required communications/connectivity capabilities must be implemented in a way that satisfies all applicable cyber security requirements related to digital controls and physical plant security. To the degree that TDDs anticipate off-site communications (e.g., for automated emergency response and fleet control centers), these challenges will extend to security of communication channels and physical equipment beyond the plant boundary.

Coupled with the increased data-centric, digital capabilities included in the scope of many TDDs, implementation will significantly increase the IT reach and profile of the plant. Vulnerabilities associated with this extended reach and profile must be identified and addressed. Accordingly, increased attention to regulatory, design, and implementation issues associated with cyber security will be necessary to successfully deploy these TDDs.

Research and development has already been conducted by EPRI and industry that drives toward deployment of this functionality; a list of references providing detailed work that supports this underpinning infrastructure is provided in Figure 5-3.

1. EPRI NMAC project on Use of LTE Cellular Network and Distributed Antenna Systems to Improve Connectivity and Increase Data Transfer in nuclear plants should receive strong consideration (2016 publication).
2. Intelligent Plant Configuration Management Using Wireless Sensors: Application to Nuclear Power Plant Valves (2015), Product ID: 3002005325
3. Initial Requirements for Wireless Sensors in Power Plant Applications (2013) Product ID: 3002001928
4. Improving the Execution and Productivity of Maintenance with Electronic Work Packages: A Mobile Work Management Initiative (2015), Product ID: 3002005363
5. Electronic Collection of As-Found Component Condition Data (2014), Product ID: 3002004690
6. Program on Technology Innovation: Machine Verification in Laser-Scanned Spaces—Status Update 1 (2014), Product ID: 3002003062
7. Advanced Nuclear Technology: Data-Centric Configuration Management for Efficiency and Cost Reduction: An Economic Basis for Implementation (2014), Product ID 3002003126
8. Cyber Security Procurement Methodology, Rev. 1 (2015), Product ID: 3002001824
9. Program on Technology Innovation: Analysis of Hazard Models for Cyber Security, Phase I (2015), Product ID: 3002004995
10. Program on Technology Innovation: Cyber Hazards Analysis Risk Methodology, Phase II: A Risk Informed Approach (2015), Product ID: 3002004997

Figure 5-3
R&D supporting plant communications/connectivity

Additional technology development will be required to provide the full functionality identified in the TDDs, including:

- Compatibility with all plant systems and automation software (note that this may vary by SMR vendor)
- Redundancy/physical hardening requirements for wireless systems
- Modularity in both wireless and software systems to allow for addition/reconfiguration to incorporate future staff-reduction technology
- Reliability and fidelity of installed capabilities

5.2.3 Automated Processes and Reporting

This common functionality element would provide consistent, common platforms and communications protocols for TDDs RP3, RP4, RP9, E2, E3, M3, M4, SC1,and O2, each of which specifies delivered functions that involve automated processing and reporting of plant data and information. Reports intended for non-company use would be automatically prepared but released by plant management action.

Specific processes and reporting capabilities identified in the TDDs that would be automated under this common functionality are:

- Personnel radiation dosimetry and reporting
- ALARA reviews and RWP generation
- Public dose assessment for emergency events
- Component and system performance reporting
- Formal plant health monitoring and reporting
- Mandatory program (e.g., motor-operated valves [MOV], air-operated valves [AOV], check valves, heat exchangers, pump performance) reporting
- Central repository database of plant/plant component (including 3-D plant model), plant process, and training/qualification information with associated analysis and reporting capability
- Work management/planning system, including standard work orders, real-time revision, and approval capability
- Component and parts procurement

Capitalizing on the potential advantages of this element of common infrastructure would require, at a minimum:

- Development of new (or adaptation of existing) database software platforms
- Definition of common data filing and storage formats that allow “one way” of accessing and using information
- Establishing communications protocols that allow interface among these databases
- Ensuring seamless compatibility among the individual TDD functionalities addressed (e.g., work management/planning, personnel qualification, outage planning)

Research and development has been already been conducted by EPRI and industry that drives toward deployment of this functionality; a list of references providing detailed work that supports this underpinning infrastructure is provided in Figure 5-4.

1. Human Factors Guidance for Control Room and Digital Human-System Interface Design and Modification: Guidelines for Planning, Specification, Design, Licensing, Implementation, Training, Operation, and Maintenance for Operating Plants and New Builds (2015), Product ID: 3002004310
2. Intelligent Plant Configuration Management Using Wireless Sensors: Application to Nuclear Power Plant Valves (2015), Product ID: 3002005325
3. Improving the Execution and Productivity of Maintenance with Electronic Work Packages: A Mobile Work Management Initiative (2015), Product ID: 3002005363
4. Program on Technology Innovation: Video Content Analytics for Nuclear Process Monitoring: A Technology Survey (2015), Product ID: 3002005367
5. Electronic Collection of As-Found Component Condition Data (2014), Product ID: 3002004690
6. Advanced Nuclear Technology: Data-Centric Configuration Management for Efficiency and Cost Reduction: An Economic Basis for Implementation (2014), Product ID: 3002003126

Figure 5-4
R&D supporting automated processes and reporting

Additional technology development will be required to provide the full functionality identified in the TDDs, including:

- Common or fully compatible database, database management, and analysis software
- Communication processes and protocols allowing data sharing among systems and functional areas
- Modularity and configurability to allow for software upgrades and changes to plant processes/reporting requirements
- Real-time validation and verification to sustain quality and correctness of end products

5.2.4 Automated Monitoring and Analysis

Several TDDs (C1, C2, RP3, RP4, RP5, RP9, E2, E3, O2) call for automated monitoring and analysis of plant component, equipment, system, operational, and personnel data, including:

- Personnel exposure
- Primary and secondary loop and auxiliary system chemical parameters
- In-plant systems radiological parameters
- Meteorological parameters and environmental radiation
- Data reduction, analysis, and reporting for chemistry and in-system radiological monitoring functions

- Component and system status, condition, and troubleshooting data
- Mandatory program (e.g., motor-operated valves [MOV], air-operated valves [AOV], check valves, heat exchangers, pump performance) status and condition data
- Plant integrated operations monitoring and analysis

Capitalizing on the potential advantages of this element of common infrastructure would require, at a minimum:

- Development of new (or adaptation of existing) software platforms for data analysis
- Definition of common data filing and storage formats that allow "one way" of accessing and using all data
- Establishing communications protocols that allow interface among the data items and analytical results and the associated reporting requirement (see Section 5.2.3)
- Ensuring seamless compatibility among the individual TDD functionalities and systems and personnel that use the data (e.g., engineering program, chemistry, and radiological technicians)

Research and development has been already been conducted by EPRI and industry that drives toward deployment of this functionality; a list of references providing detailed work that supports this underpinning infrastructure is provided in Figure 5-5.

1. Human Factors Guidance for Control Room and Digital Human-System Interface Design and Modification: Guidelines for Planning, Specification, Design, Licensing, Implementation, Training, Operation, and Maintenance for Operating Plants and New Builds (2015), Product ID: 3002004310
2. Intelligent Plant Configuration Management Using Wireless Sensors: Application to Nuclear Power Plant Valves (2015), Product ID: 3002005325
3. Program on Technology Innovation: Video Content Analytics for Nuclear Process Monitoring: A Technology Survey (2015), Product ID: 3002005367
4. Improving the Execution and Productivity of Maintenance with Electronic Work Packages: A Mobile Work Management Initiative (2015), Product ID: 3002005363
5. Electronic Collection of As-Found Component Condition Data (2014), Product ID: 3002004690
6. Advanced Nuclear Technology: Data-Centric Configuration Management for Efficiency and Cost Reduction: An Economic Basis for Implementation (2014), Product ID: 3002003126

Figure 5-5
R&D supporting automated monitoring and analysis

Additional technology development will be required to provide the full functionality identified in the TDDs, including:

- Common or fully compatible database, database management, and analysis software
- Communication processes and protocols allowing data sharing among systems and functional areas
- Modularity and configurability to allow for software upgrades and changes to plant processes/reporting requirements
- Specific analytical metrics applicable to SMR operation and reporting requirements
- Real-time validation and verification to sustain quality and correctness of results

5.2.5 Automated Procedures and Training

Automated procedures and training functionally bridges TDDs M2, M4, O2, and T1. TDDs M4 and O2 build upon several of the previously identified common functionality elements in this section (data-centric plant information and configuration management system; communications/connectivity; and automated monitoring, analysis, and reporting) to facilitate standardized work orders with real-time revision/approval capability and worker tracking (M4) in addition to automated electronic procedures and plant logs (O2). Advanced training methodologies such as virtual simulator-based training, serious games, and self-training capabilities will facilitate implementation of TDDs M2 and T1. For M2, advanced training techniques will reduce the plant training tax required to cross-train technicians, while for T1, cutting-edge training will optimize instructor and simulator resource usage.

Specific functionality elements identified in the TDDs that are enabled by procedure automation are:

- Standardized work orders
- Real-time revision and approval capability
- Worker tracking
- Automated plant logs (including narrative entries)

Specific staff optimization areas identified in the TDDs enabled by adoption of advanced, technology-based training methods are:

- Use of multiskilled, cross-qualified personnel for maintenance, inspection, radiation protection, and some engineering functions
- Reduction in staff resources required to train personnel
- Reduction in absolute time and calendar time to train personnel
- Reduction in simulator resources required to train personnel
- Optimized use of instructor and simulator training time

Capitalizing on the potential advantages of automating procedures would require, at a minimum:

- Development of new (or adaptation of existing) procedure automation software platforms

- Development of new (or adaptation of existing) database software platforms
- Definition of common data filing and storage formats that allow "one way" of accessing and using information
- Establishing communications protocols that allow interface among these databases
- Ensuring seamless compatibility among the individual TDD procedures addressed (e.g., standardized work orders, revision and approval capability, automated plant logs)

Capitalizing on the potential advantages of advanced training techniques would require, at a minimum:

- Development of new (or adaptation of existing) plant-tailored training software (e.g., virtual simulators, serious games, self-training capabilities)
- Comprehensive workload analysis of positions identified for cross-training
- Comprehensive analysis of positions identified for elimination as a result of cross-training
- Development of comprehensive qualification and proficiency maintenance standards for cross-trained personnel

Research and development has been already been conducted by EPRI and industry that drives toward deployment of this functionality; a list of references providing detailed work that supports this underpinning infrastructure is provided in Figure 5-6.

1. Human Factors Guidance for Control Room and Digital Human-System Interface Design and Modification: Guidelines for Planning, Specification, Design, Licensing, Implementation, Training, Operation, and Maintenance for Operating Plants and New Builds (2015), Product ID: 3002004310
2. Intelligent Plant Configuration Management Using Wireless Sensors: Application to Nuclear Power Plant Valves (2015), Product ID: 3002005325
3. Program on Technology Innovation: Video Content Analytics for Nuclear Process Monitoring: A Technology Survey (2015), Product ID: 3002005367
4. Improving the Execution and Productivity of Maintenance with Electronic Work Packages: A Mobile Work Management Initiative (2015), Product ID: 3002005363
5. Capturing and Using High-Value Undocumented Knowledge in the Nuclear Industry: Guidelines and Methods (2002), Product ID: 1002896
6. Application of Virtual Reality and Simulation Technologies to Improve Worker Training and Performance, Work Planning, and Facility Design and Evaluation (13-Apr-2011), Product ID:1022310

Figure 5-6
R&D supporting automated procedures and training

Additional technology development will be required to provide the full functionality identified in the TDDs, including:

- Common or fully compatible database, database management, and analysis software
- Communication processes and protocols allowing data sharing among systems and functional areas
- Modularity and configurability to allow for software upgrades and changes to plant procedures
- Comprehensive review of task-to-position requirements specific to individual SMR designs
- Best practices and procedures for cross-training expert personnel in reduced manning, increased automation environments

5.3 Master Plant Digital and Communications Backbone

There are higher-level potential synergies across the common functions and infrastructure. One direction that could be taken in capitalizing on these higher-level synergies would be development of a master plant digital and communications backbone that would address all of the functions and infrastructure platforms identified in Sections 5.2.1 through 5.2.5.

Assuming cyber security issues can be resolved (see Section 5.2.2), implementing a plant digital backbone would allow optimizing development and implementation of many TDDs (identified in the previous subsections). This approach would also allow optimization of staff savings by consolidating the IT support staff necessary to maintain the backbone, as well as facilitating additional staff savings through enhanced capability for remote or fleet operations and control.

Coordination could be addressed in aspects such as:

- Using the same or compatible hardware (e.g., servers, monitors) and software (e.g., data management) packages for similar functions
- Using compatible architecture for all digital, automated elements and communications elements
- Developing common communications protocols and data formats (e.g., a standard plant information model) that allow interface among the common functions and infrastructure elements
- Incorporating all TDD requirements into the design of functional elements (e.g., 3-D model, wireless communications) utilized in multiple TDDs

Thus, if multiple TDDs are selected for application in SMR plants, significant efficiencies can be achieved in both development and implementation by coordinating design of these common elements.

Finally, it should be noted that greater reliance on digital infrastructure and connectivity comes with increased IT and I&C staff requirements, primarily due to installation, operation, and maintenance of necessary hardware and software, coupled with an increased need for robust and persistent cyber security measures. These requirements may partially offset the staff reductions enabled by greater internal and external communications capability, but as noted throughout this report, the staffing reductions provided by common functions and infrastructure through a comprehensive plant digital backbone would be significant. On balance, the incremental increase in IT and I&C support is significantly exceeded by the overall staff reductions achieved in other plant functions.

A
NUCLEAR POWER PLANT STAFF FUNCTIONAL AREAS

The following staff functional areas were used as the framework for identifying specific activities or activity types in which potential staff reductions could be achieved by implementing the technologies and design details. Each TDD (Appendix C) includes a heading that identifies the primary functional areas(s) that would be affected by TDD implementation.

A.1 Chemistry

Code	Functional Area
CF-1	Abnormal or Emergency
CF-2	Administrative
CF-3	Obtain/maintain waste water, potable water and/or biological certification (state)
CF-4	Analytical Equipment
CF-5	Operate/Maintain Inline Analyzers
CF-6	Chemical Addition
CF-7	Conventional Island Chemical Feed System
CF-8	Chemistry Analysis
CF-9	Collect Samples
CF-10	Collect local grab samples
CF-11	Collect corrosion product transport filters
CF-12	Emergency Response Organization
CF-13	Environmental Chemistry
CF-14	Prepare NPDES samples
CF-15	Laboratory Quality Control Activities
CF-16	Make-up Water Chemistry
CF-17	Material Handling
CF-18	ODCM
CF-19	Operate Systems
CF-20	Petroleum analysis
CF-21	Primary Water Chemistry
CF-22	Secondary Water Chemistry

A.2 Radiation Protection

Code	Functional Area
RPF-1	Administrative
RPF-2	Control of Airborne Radioactivity
RPF-3	Decontamination
RPF-4	Dosimetry and Records Keeping
RPF-5	Environmental Monitoring
RPF-6	Exposure and Work Control
RPF-7	Instrument Repair and Calibration
RPF-8	Calibrate and maintain portable survey instruments
RPF-9	Calibrate and maintain fixed instruments
RPF-10	Calibrate and perform maintenance on fixed personnel monitoring equipment
RPF-11	Calibrate and perform maintenance on the air sampling equipment
RPF-12	Dosimetry equipment
RPF-13	Operation of Portable Survey Instruments
RPF-14	Operate survey instruments
RPF-15	Operate Continuous Air Monitors (CAMs)
RPF-16	Operation of Fixed Laboratory Instrumentation
RPF-17	Operate bench gross counting instruments
RPF-18	Perform Radiation and Contamination Surveys
RPF-19	Conduct radiological survey
RPF-20	Preparation/Shipment/Receipt of Radioactive Material
RPF-21	Provide Radiological Job Coverage
RPF-22	Perform remote monitoring operations
RPF-23	Radiation Protection Support for Operations
RPF-24	Radioactive Material Control, Movement and Storage on Owner Controlled Property
RPF-25	Respiratory Protection Equipment Maintenance
RPF-26	Respond to Radiological Alarms
RPF-27	RP Emergency Response
RPF-28	Industrial Hygiene

A.3 Maintenance

Code	Functional Area
MF-1	Maintenance Training
MF-2	Work Planning and Scheduling
MF-3	Job Scoping, Troubleshooting and Walkdown
MF-4	Work Package Implementation
MF-5	Corrective Maintenance
MF-6	Preventive Maintenance
MF-7	Work Site Prep (scaffolding et al.)
MF-8	Tools and Instruments
MF-9	Warehousing
MF-10	Equipment Monitoring

A.4 Engineering (See A.11 for Expansion)

Code	Functional Area
EF-1	Engineering Change Process
EF-2	Reactor Engineering Administration
EF-3	Procurement Requisition Process
EF-4	Plant Modifications
EF-5	ERO EOF Technical Support Engineer
EF-6	Program Management
EF-7	PRA Engineering
EF-8	Digital Administration
EF-9	Corrective Action Process
EF-10	Engineering Training
EF-11	System Engineering/Monitoring
EF-12	Component Engineering/Troubleshooting

A.5 Operations

Code	Functional Area
OP-1	Plant Configuration Control (includes system lineup)
OP-2	Plant Operations (Normal, Abnormal, Emergency, BDBE, Refueling, Start up, Radwaste, Switchyard)
OP-3	Operations Training (includes all required training)
OP-4	Work Control (includes Clearance & Tagging, work package review, work authorization, scheduling, etc.
OP-5	Testing (Surveillance, ASME Code, Post Maintenance, Post Modification)
OP-6	Preventative Maintenance
OP-7	Operations Logs
OP-8	Operations Procedure Review & approval
OP-9	Outage Support
OP-10	Reactivity Control
OP-11	Plant Material Condition (includes equipment protection)
OP-12	Tools and Instruments
OP-13	Equipment Lubrication
OP-14	Safe Shutdown from outside Control Room
OP-15	Observation Program (in-plant, training, control room)
OP-16	Refueling Operations (including new fuel receipt)
OP-17	Safety (Nuclear, Personal, Radiological)
OP-18	Electric Generation
OP-19	Gas Turbine Operations - when installed
OP-20	Emergency Plan Implementation
OP-21	Spill Control Implementation
OP-22	Security Plan compliance
OP-23	Operations Qualifications
OP-24	Corrective Action Program
OP-25	Inspection Support (NRC, INPO, NEIL, etc.)

A.6 Outage Management

Code	Functional Area
OM-1	Develop and Maintain Base Outage Schedule (e.g. refueling and regulatory driven activities such as surveillances)
OM-2	Develop and Maintain Outage Risk Management Software and Plan
OM-3	Maintain Forced Outage Scope and Schedule
OM-4	Participate in Industry Meetings/ Initiatives to Improve Outage Performance
OM-5	Outage Goals Development (cost, dose, length, etc.)
OM-6	Coordinate with Load Dispatchers for Availability of Plant
OM-7	Integrate Design Changes into Outage Plan
OM-8	Integrate Major Equipment (Life Cycle Management) Plan into Outage Schedules
OM-9	Integrate Shutdown PRA into Outage Schedule
OM-10	Develop and Maintain Outage Budget
OM-11	Integrate Fuel Configuration Needs into Outage Schedule
OM-12	Ensure Supplemental Resources are Available (craft, OEM, special vendors, etc.)
OM-13	Integrate Outage Related Maintenance Work into Outage Schedule
OM-14	Develop Specific Outage Work Sequences and Logic and Issue Draft and Final Schedules
OM-15	Levelize Outage Schedule Based on Resource Availability into Draft Schedules
OM-16	Develop and Management High Impact Teams as needed
OM-17	Communicate Outage Preparation Status and Priorities to Organization (e.g. Pre-outage Outage Meetings)
OM-18	Assist in Obtaining Fleet Resources if applicable
OM-19	Assist in Obtaining Supplemental Resources
OM-20	Develop Startup Testing Requirements and Schedule
OM-21	Coordinate Supplemental Workforce Training Requirements
OM-22	Develop Outage Related Clearance & Tagging Packages
OM-23	Coordinate Supplemental Workforce Oversight Requirements
OM-24	Integrate Required Outage PMs into the schedule
OM-25	Integrate all required ISI and Surveillance Testing into the outage schedule
OM-26	Monitor Outage Work vs. Schedule
OM-27	Assess and Manage Plant Configuration for Risk Purposes
OM-28	Update Schedule Based on Work Progress and Scope Changes
OM-29	Manage Incoming Outage Scope and Outage Scope Cuts
OM-30	Manage Outage Issues that Arise
OM-31	Communicate Outage Execution Status and Priorities to Organization (e.g., Outage Meetings)

Code	Functional Area
OM-32	Manage the Outage Control Center
OM-33	Manage the Outage Refueling Contract
OM-34	Collect and Assess Outage Improvements
OM-35	Manage Outage Improvement Actions
OM-36	Perform Outage Critiques
OM-37	Incorporate Outage Improvement Actions into Future Schedules and Process/Procedures

A.7 Training

Code	Functional Area
TR-1	Task List Maintenance (Ops, Maintenance, IC, Elec, Chemistry, RP)
TR-2	Training Program Accreditation (Ops, Maintenance, IC, Elec, Chemistry, RP)
TR-3	Training Program Accreditation Renewal (Ops, Maintenance, IC, Elec, Chemistry, RP)
TR-4	Continuing Training Program Development and Execution (Ops, Maintenance, IC, Elec, Chemistry, RP)
TR-5	Mock up development and maintenance
TR-6	Just in Time Training Program
TR-7	Training Program Documentation
TR-8	Training Records
TR-9	Instructor Training & Qualification
TR-10	Instructor Outage Support
TR-11	Instructor Classroom Observation Program
TR-12	OJT Program Administration
TR-13	Qualification Card development and maintenance
TR-14	In plant task Testing and Qualification
TR-15	Training Materials development and maintenance
TR-16	Training Procedure Development and Maintenance
TR-17	Professional Training Program Task List Maintenance (Engineer, Supervisor, Work Planner, etc.)
TR-18	Professional Training Program Accreditation (Engineer, Supervisor, Work Planner, etc.)
TR-19	Professional Training Program Accreditation Renewal (Engineer, Supervisor, Work Planner, etc.)
TR-20	Professional Continuing Training Program (Engineer, Supervisor, Work Planner, etc.)
TR-21	Professional Training Program Qualification Card Development (Engineer, Supervisor, Work Planner, etc.)
TR-22	Training Program Feedback (Collection and Review)

Code	Functional Area
TR-23	Training Program Liaison with Plant Staff
TR-24	Management observation of Training
TR-25	Training Program Review & Audit
TR-26	Training Program Ongoing Improvement
TR-27	Training Program Management

A.8 Emergency Preparedness

Code	Functional Area
EP-01	ERO duty Assignments and Staffing Management
EP-02	Emergency Direction – Command and Control
EP-03	Communications and Notifications – States, Counties, NRC (ERDS), Media
EP-04	Offsite Dose Assessment, Meteorology, Source Term Identification
EP-05	Offsite Radiological Surveys
EP-06	Onsite surveys, Radiochemistry, Dose Tracking
EP-07	Emergency Repair – Mechanical, Electrical, I&C, HP support
EP-08	Physical Security and Access Control of Emergency Facilities
EP-09	Personnel Accountability
EP-10	Firefighting and Fire protection
EP-11	Rescue and First Aid
EP-12	Evacuation – Site
EP-13	Evacuation – EPZ
EP-14	Hostile Action Management
EP-15	Support Service Management – Local fire, police, Food Service, Lodging
EP-16	Remote and Alternate Facility Implementation
EP-17	Common Facility Implementation
EP-18	Drill and Exercise Management

A.9 Warehousing & Supply Chain

Code	Functional Area
Supply Chain	
SC-01	Negotiate for Engineering / BOM Information in original EPC Contract
SC-02	Negotiate Proactive Obsolescence Tracking System
SC-03	Develop Sourcing Strategy
SC-04	Review Purchase / Contract Request (line item)
SC-05	Combine line items – Create Purchase Order, Contract / Blanket Release
SC-06	Create Request for Quote / Analyze Quotes
SC-07	Negotiate / Establish Pricing and Delivery
SC-08	Award Purchase Order or Contract
SC-09	Manage resolution of Purchase Order / Contract Deviation Request / Problems
SC-10	Expedite Delivery
SC-11	Approve Payment
SC-12	Supplier Performance Monitoring
SC-13	Accounts Payable
Warehousing	
WH-01	Create Stock Code
WH-02	Request Replenishment
WH-03	Receiving
WH-04	Put-Away
WH-05	Store
WH-06	Facilitate In-Storage Maintenance
WH-07	Facilitate Shelf Life Program
WH-08	Cycle Count
WH-09	Pick
WH-10	Stage
WH-11	Issue
WH-12	Package
WH-13	Ship
Procurement Engineering	
PE-001	Component Safety Classification
PE-002	Component Criticality Classification

Code	Functional Area
PE-003	Build / Update BOM
PE-004	Part Safety Classification
PE-005	Part Criticality Classification
PE-006	Build Obsolescence Tracking System
PE-007	Determine Current Availability
PE-008	Identify Proposed Replacement
PE-009	Equivalency Evaluation
PE-010	Initiate Design Change
PE-011	Commercial Grade Dedication Evaluation
PE-012	Initiate Audit/Survey Request
PE-013	Update Stock Code Tech & QA Requirements
PE-014	Develop Storage and Handling Requirements
PE-015	Resolve QC Receiving / Purchasing Discrepancies
PE-016	Disposition QC Receiving Purchasing Discrepancies

A.10 Security

Security functions were as considered by the NEI Security working group.

A.11 Supplemental Engineering Functions

SME involved with the project considered Engineering functions beyond those summarized in A.4. They are included here as perspective of persons pursuing more granular staffing optimization in Engineering.

Code	Primary Engineering Functions	Code	Sub-Function
EF-1	**Engineering Change Process**	**Engineering Change Function (ECF)**	
		ECF-1	Calculation Control
		ECF-2	Drawing Control
		ECF-3	Database Control
		ECF-4	ASME Specification Control
		ECF-5	Design Basis Documents (DBDs)
		ECF-6	Vendor Manuals and Information
		ECF-7	Procurement Process Overview

		ECF-8	EQ Overview
		ECF-9	Review & Verification
		ECF-10	Software Tools
		ECF-11	Software Control
		ECF-12	Equipment Classification
		ECF-13	Operability Recommendations (ES-120)
		ECF-14	Cyber Security Basics
EF-2	**Reactor Engineering Administration**		
		Reactor Engineering Function (REF)	
		REF-1	Fuel and Core Component Handling
		REF-2	New Fuel Receipt and Inspection
		REF-3	Post Refueling Startup Testing
		REF-4	Power Distribution Measurement
		REF-5	Reactivity Balance
		REF-6	Shutdown Margin
		REF-7	Reactor Startup (Post Initial Startup)
		REF-8	SNM Program
		REF-9	Preparation of Operating Guidelines
		REF-10	QPTR Determination
		REF-11	RE Software Controls
		REF-12	Curve Book Administration
		REF-13	BEACON Calibration and Maintenance
		REF-14	Leading Edge Flow Meter Operation
		REF-15	SNM Inventory Reporting
		REF-16	PQ/PE Orientation
EF-3	**Procurement Requisition Process**		
		Procurement Process Function (PPF)	
		PPF-1	Requests For Disposition

		PPF-2	Development of Procurement Tech. Requirement Doc.
		PPF-3	Equal To/Better Than Evaluations
		PPF-4	ASME Code Reconciliation
		PPF-5	Audit Technical Support
		PPF-6	CHAMPS CMMS Inventory Proficiency
		PPF-7	Equipment Qualification (Intermediate PE/PQ)
		PPF-8	Equipment Qualification (Advanced)
		PPF-9	Quality Reviews
EF-4	**Plant Modification – Commercial Changes**		
		Plant Modification – Commercial Function (PMCF)	
		PMCF-1	Commercial Changes
		PMCF-2	Set point Changes
		PMCF-3	Equipment Classification
		PMCF-4	Flow-Accelerated Corrosion Program
		PMCF-5	Seismic
		PMCF-6	Piping Analysis
		PMCF-7	Fire Protection
		PMCF-8	Plant Lubrication Program
		PMCF-9	Appendix R
		PMCF-10	Pipe Supports
		PMCF-11	Cable and Circuit Routing
		PMCF-12	Equipment Qual. (Intermediate DE)
EF-5	**ERO EOF Technical Support Engineer**		
		ERO EOF Function (EROEOFF)	
		EROEOF-1	ERO EOF Plant Status Communicator
		EROEOF-2	ERO EOF Major Events Logger
		EROEOF-3	ERO EOF Technical Support Coordinator
EF-6	**Program Management**		
		Program Management Function (PMF)	
		PMF-1	ASME Sec. XI In-Service Inspection

		PMF-2	Human Factors Engineer
		PMF-3	NFPA 805 Cir. Selection Routing & Analysis
		PMF-4	NFPA 805 Shutdown Analysis
		PMF-5	NFPA 805 Fire Modeling
		PMF-6	NFPA 805 Detailed Fire Modeling
		PMF-7	Seismic Baseline Walkdown Inspections and Evaluations
		PMF-8	PSE Admin and Indoctrination
		PMF-9	Trending and Preventive Maintenance
		PMF-10	Maintenance Rule
		PMF-11	Technical Support Center Duties
		PMF-12	NC/Cause and Corrective Action Evals
		PMF-13	Testing
		PMF-14	ASME Section XI
		PMF-15	Equipment Qual. (Interm. PSE)
		PMF-16	MOV Program
		PMF-17	Snubbers
		PMF-18	AOV Component Engineer
		PMF-19	Boric Acid Corrosion
		PMF-20	Pressure Relief Valve Engineer
		PMF-21	Check Valve Engineer
		PMF-22	Maintenance Rule Program Owner
		PMF-23	Plant Lubrication Program
		PMF-24	Heat Exchanger Program
		PMF-25	Scaffolding, Shielding, and Storage Evaluations
		PMF-26	Thermal Performance Program
		PMF-27	Equipment Reliability
		PMF-28	Scaffold Evaluations
		PMF-29	Shielding Evaluations
		PMF-30	Storage Evaluations
		PMF-31	Buried Pipe Integrity Program
		PMF-32	Electric Cable Reliability Monitoring Program

		PMF-33	Leak Reduction Program
		PMF-34	Flow-Accelerated Corrosion Program
		PMF-35	Steam Generator Management Program
EF-7	**PRA Engineering**		
		PRA Function (PRAF)	
		PRAF-1	PSA: Human Reliability Analysis
		PRAF-2	PSA Risk Assessment
		PRAF-3	PRA Model Development
		PRAF-4	PSA Data Updating
		PRAF-5	PSA: Equipment Out of Service (EOOS)
		PRAF-6	PSA: Mitigating System Performance Index
		PRAF-7	Fire PRA
EF-8	**Digital Administration**		
		Digital Administration Function (DAF)	
		DAF-1	Digital Design
		DAF-2	Software Quality Assurance (SQA)
		DAF-3	Digital Maintenance
		DAF-4	Cyber Security Technician
EF-9	**Corrective Action Process**		
EF-10	**Engineering Training**		

B

TECHNOLOGY AND DESIGN DETAIL (TDD) WRITERS' GUIDE

General Guidance: A TDD, properly completed, should contain sufficient detail that a competent design organization could understand the intent and expectations of the TDD and proceed to perform the evaluations and create the technical details necessary to incorporate the TDD into a plant design. If the subject of the TDD needs further development, the TDD should contain sufficient details that a competent research and development organization could understand the development needs and pursue necessary projects to make the subject of the TDD usable on a project.

The following is the format for TDDs with guidance for content under each header.

TDD-X# Assigned number based on Discipline – example Chemistry #1 = TDD-C1

Priority Rank X Priority ranking as assigned by the TAG using 4 quadrant matrix (A, B, C, D)

Responsible Team: Completes the first draft of the TDD for full TAG review

TAG: Comments on proposed and adds content to increase the value of the TDD

SME: Comments on proposed and adds content to increase the value of the TDD

EPRI Project: Drafts proposed TDD

Technology and Design Details:

This header contains a very clear word description of the technology and/or design detail we are striving to address. Focus on communicating the idea. Include important expectations under the appropriate "Assumptions" headers that follow.

Development Needs:

This header declares that existing technologies and design understanding necessary to successfully incorporate the subject of this TDD into the plant design is or is not sufficient. If there are no developmental needs, please state "None". The TDD topic is considered ready for design incorporation.

Frequently one or more aspects of the TDD topic can be "developed" to increase and/or sustain the staffing impact of the topic. If this is the case, please state that topic needs to be "Enhanced", then describe the enhancement needed. The TDD topic itself can be pursued by an SMR design team independent of the enhancement.

Some TDD topics are not ready to be included in evolving SMR designs. If this is the case, please state that the topic needs "Essential" development. In this case this header should contain the necessary development needs that should be accomplished prior to a project giving serious consideration to including the TDD. These are still high value staffing impact TDDs. They just need additional work before a project can include them.

Design Assumptions:

This header is not intended to capture all normal design assumptions. It is intended to capture those important design assumptions that are critical for the subject of the TDD to accomplish the expected and potential staffing impacts. These are cautions to call out "don't forget about this when you incorporate the subject of this TDD into the design of the plant and instructions for the project". If there are no design assumptions, please state "None".

Project Management and Construction Assumptions:

This header is not intended to capture all normal project management and construction assumptions. It is intended to capture those important project management and construction assumptions that are critical for the subject of the TDD to accomplish the expected and potential staffing impacts. These are cautions and expectations to call out "don't forget that the staffing benefits created in design can be compromised and/or lost by actions during project management and construction". If there are no project management or construction assumptions, please state "None".

Plant Operation Assumptions:

This header is not intended to capture all normal plant operation assumptions. It is intended to capture those important plant operation assumptions that are critical for the subject of the TDD to accomplish the expected and potential staffing impacts. These are cautions and expectations to call out "don't forget you can lose the staffing benefits created by this TDD by actions during plant operations". If there are no plant operation assumptions, please state "None".

Key captured information:

This header is to capture references to existing work that would be important to persons assigned to proceed with the design incorporation and/or development needs of the TDD. The references and insights captured do not need to be all inclusive but should capture those that come to light during the discussion and population of the TDD. These might include NEI, INPO and EPRI documents; standards and regulations of note; known applications of the subject of the TDD that should be evaluated for lessons learned.

Regulatory:

This header should capture any unique and/or notable regulatory actions necessary to consider/address prior to inclusion of the subject of the TDD into a plant design. Normal regulatory review and acceptance need not be called out unless there are known "hard spots" that must be addressed during the normal review.

Functional Area:

This header should capture the primary functional areas of the plant discipline being considered that are impacted most significantly by the TDD. These should be selected from the assembled listing of primary functions for the discipline under consideration. If other plant disciplines are also significantly impacted, they should also be called out.

Potential staffing impact:

This header should contain a best description and/or approximation of staffing impact that would result from application of this TDD. It is not the expectation that exhaustive efforts be undertaken to create staffing impact numbers. However, best guess estimates by subject matter experts and/or the TAG (technical advisor group) should be included if available. If not, a word description of the staffing impact should be provided.

Other comments provided for perspective and insight for the next group working with this TDD:

This header should contain any additional perspective and insight not captured in the other headers that would be useful to the next group or person assigned to carry the subject of the TDD forward. Include the information here or under the other headers that you would want to know if you were the next accountable person assigned to implement the TDD.

Proposed next steps:

This header should contain the sense of the TAG for the next rational step for the TDD. This may be an action for another organization (i.e. EPRI should establish a follow-on project to address X). As a minimum each TDD accepted by the TAG will be considered for inclusion or reference in the EPRI Utility Requirements Document (URD) for Advanced Light Water Reactors including Small Modular Reactors. The TDD should cite one or more URD sections for potential revision.

C

TECHNOLOGY AND DESIGN DETAIL (TDD) DESCRIPTIONS

This appendix contains the full text of each of the TDDs developed using the processes laid out in Section 2 of this report. All of these descriptions have been reviewed by many technical experts and are presented in their context to communicate requirements or to share important information and insights. Users should consider each sentence as written.

TDD Index

TDD Number	TDD Title
C1	Automated Sampling and Analysis – Chemical
C2	Automated Sampling and Analysis – Radiological
C3	Chemical and Radiological Analysis Software Suite
RP3	Automated Personnel Monitoring and Dosimetry
RP4	Automated ALARA Job Reviews and RWP Generation
RP5	Automated Radiation Monitoring and Analysis
RP9	Automated Public Dose Assessment for EP
M1	Standardized Components
M2	Cross-Training of Maintenance Staff
M3	Connectivity
M4	Automated Electronic Mobile Work Management
M5	Design for Maintenance Effectiveness and Efficiency
E1	Engineering Tool Set
E2	Automated Plant Health Management System Assuring Plant and Equipment Reliability
E3	Program Engineering Automation
O1	Intelligent Configuration Management Optimization
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures
T1	Use of Advanced, Technology-Based Training Methods
EP1	Use of IPAWS Public Notification System for Emergency Communications

TDD Number	TDD Title
EP2	Remote and Alternate Facility Implementation
SC1	Supply Chain and Procurement Engineering Tools
WH1	Automated Parts Supply
S1	Target Set Reduction
S2	Security Barrier Location and Effectiveness
S3	Design Vulnerability Reduction

TDD-C1 Automated Sampling and Analysis – Chemical
Priority Rank: B

Responsible Team:
TAG: James Mallon
SME: Joel McElrath; Rick Reid
EPRI Project: Kyle Turner

Technology and Design Details:
Real-time, online, automated (e.g., calibration), high reliability process fluid sampling, analysis and reporting capability based on primary, secondary, and auxiliary water chemistry parameters from EPRI and original equipment manufacturer (OEM) guidelines. The system would be Integrated across all units/modules and be compatible with off-site monitoring and management of chemistry parameters.

Development Needs:
Enhanced:
- Need technology development for inline measurement (monitors) of parameters:
  - Primary loop Lithium
  - Corrosion products (includes analysis)
- EPRI chemistry guidelines need to be reviewed and optimized for SMR in general and for the design specifics of unique SMR designs.
- Assessment of existing, available instrumentation against reliability requirements, listing of variables needed, and self-monitoring and calibrating capability.

Essential:
- Instrument environmental qualification – maximal tolerance to plant conditions

Design Assumptions:
- Provisions for placement of and access to inline monitors
- Provisions for parallel manual sampling, as required, for QA/QC & backup
- Provisions for ensuring environmental conditions necessary for inline Instrument operation are maintained

Project Management and Construction Assumptions:
- None.

Plant Operational Assumptions
- Plant chemistry and operations programs and procedures fully utilize the capability of this system. They are written so that no routine on-shift chemistry support is necessary.

- It is assumed that any needed chemical addition will be accomplished by normal shift operations personnel, or by means of automated chemical injection.

Key captured information:

- EPRI guidelines:
  - Pressurized Water Reactor Primary Water Chemistry Guidelines: Revision 7, Volumes 1 and 2, Product ID: 3002000505, 24-Apr-2014
  - Pressurized Water Reactor Secondary Water Chemistry Guidelines - Revision 7, Product ID:1016555,:17-Feb-2009
  - Remote Monitoring Technology Interim Report: Industry Best Practices and Lessons Learned, Product ID:1013508, 28-Nov-2006
  - Proceedings: Remote Monitoring Technology 2008 Workshop, Product ID: 1019491, 31-Jul-2009
  - Closed Cooling Water Chemistry Guidelines – Revision 2, Product ID: 3002000590, Dec-2013
  - Open Cooling Water Chemistry Guidelines, Product ID: 1025318, Sep-2012

Regulatory:
Requires detailed review of SMR proposed and/or standard Technical Specifications to assure the proposed system can be used to its maximum capability and achieve the staffing intents.

Functional Areas:
CF-5 Operate/Maintain Inline Analyzers, CF-8 Chemistry Analysis, CF-9 Collect Samples

Potential staffing annual impact:
CF-5 will see a low increase (~2 FTE) due to increased number and complexity of monitors, CF 8 and 9 should see a high decrease (~8 FTE) due to elimination of need for shift technicians

Other comments provided for perspective and insight for the next group working with this TDD:

- There could be linkages to and synergies with TDD C2 and C3.
- In-progress EPRI study on inline instrumentation implementation (Enhanced On-Line Monitoring of Ionic Species in Boiling Water and Pressurized Water Reactors, 2016 deliverable).
- We did not assess the current state of the art of software or monitors to fulfill this need. Our experience leads us to believe that most if not all of these capabilities can be achieved through assembly of existing technologies with upgrades as needed for this application.

Proposed next steps:

- EPRI
  - Conduct assessment of existing, available instrumentation against in-line chemistry monitoring instrument requirements, including environmental qualification
  - Review and update guidelines for in line chemistry monitoring equipment taking into account SMR design characteristics
  - Include pertinent requirements and expectations in the targeted review list for the next revision of SMR URD.
  - Initiate technology development project for inline monitoring of:
    - Primary loop Lithium
    - Corrosion products (includes analysis)
- NEI
  - Incorporate the capabilities of this TDD into the evolving standard Technical Specifications for SMR.

TDD-C2 Automated Sampling and Analysis – Radiological
Priority Rank: C

Responsible Team:
TAG: Dan Stout
SME: Robert Martin; Rick Reid; Phung Tran
EPRI Project: Kyle Turner

Technology and Design Details:
Real-time, online, automated (e.g., calibration), high reliability sampling, analysis and reporting capability for in-plant systems radiological parameters including online gamma spectroscopic analysis and primary loop Nitrogen-16 off gas monitoring. The system would be Integrated across all units/modules and be compatible with off-site monitoring and management of radiological parameters.

Development Needs:
Enhanced:

- Need technology development for inline measurement using the following technologies:
  - Cadmium zinc telluride (CZT) as an alternative for cryogenically cooled scintillator technologies
  - Non-scintillation tritium monitoring technology
  - Isokinetic sampling elimination
- Conduct assessment of existing, available instrumentation against in-line radiological parameters monitoring instrument requirements, including environmental qualification

Essential:

- Inline gamma spectrometry capability

Design Assumptions:

- Provisions for placement of and access to inline monitors in low background or shielded locations
- Provisions for parallel manual sampling, as required, for QA/QC & backup
- Provisions for ensuring environmental conditions necessary for inline Instrument operation are maintained

Project Management and Construction Assumptions:
None.

Plant Operational Assumptions

- Plant chemistry, radiological monitoring and operations programs and procedures fully utilize the capability of this system. They are written so that no routine on-shift radiological monitoring support is necessary.

Key captured information:
None.

Regulatory:

- Additional technology development necessary before regulatory analysis. Incorporate the capabilities of this TDD into the evolving standard Technical Specifications for SMR, as applicable based on regulatory analysis

Functional Areas: CF-5 Operate/Maintain Inline Analyzers, CF-8 Chemistry Analysis, CF-9 Collect Samples

Potential staffing annual impact:
CF-5 will see a low increase (~2 FTE) due to increased number and complexity of monitors, CF 8 and 9 should see a low decrease (<5 FTE) due to elimination of need for shift technicians duties

Other comments provided for perspective and insight for the next group working with this TDD

- Examine and take into account staff reduction synergies with chemistry monitoring (TDD-C1).
- Examine CANDU plant experience & techniques for tritium monitoring.

Proposed next steps:

- EPRI
  - Conduct assessment of existing, available instrumentation against in-line radiological parameters monitoring instrument requirements, including environmental qualification
  - Develop guidelines for in line radiological parameters monitoring equipment
  - Include pertinent requirements and expectations in the targeted review list for the next revision of SMR URD.
  - Initiate technology development project for development of:
    - Inline gamma spectrometry capability
  - Initiate technology development project to evaluate feasibility for in line monitoring technologies:
    - Cadmium zinc telluride (CZT) detectors or similar technology as an alternative for cryogenically cooled scintillator technologies
    - Non-scintillation tritium monitoring technology
    - Isokinetic sampling elimination

- NEI
  - Conduct regulatory analysis based on technology and guideline development results, as described above
  - Incorporate the capabilities of this TDD into the evolving standard Technical Specifications for SMR, as applicable based on regulatory analysis

TDD-C3 Chemical and Radiological Analysis Software Suite
Priority Rank: C

Responsible Team:
TAG: Spencer Semmes
SME: Joel McElrath; Rick Reid
EPRI Project: Kyle Turner

Technology and Design Details:
Software suite that performs all data reduction, analysis, and reporting for chemistry and in-system radiological monitoring functions, and generates reports in forms and content suitable for multiple (all) users

Development Needs:
Essential:

- Evaluation of existing, available software data management suites to determine whether they can be adapted, and, if not, what how they would need to be augmented to provide the needed functionality, including:
  - Expandable to track evolving requirements, fleet implementation, and extension to a larger population of plant data
  - Forward compatibility to accommodate future evolution of hardware platforms
- Conduct of validation and software quality assurance review/testing of resulting software suite.

Design Assumptions:

- Specific emphasis is placed on the essential needs and uses of user groups to assure that software suite out puts are practical, usable and accomplish the intended staffing optimization.
- Accept inputs from commercially available analytic equipment
- Trend capability for all monitored data with ability to highlight adverse trends or alarm points
- Accomplish Plant Operation assumption below.

Project Management and Construction Assumptions:
None.

Plant Operation Assumptions:

- The suite developed is sufficiently credible and reliable that operations personnel are confident in making operational decisions based on system outputs independent of subject matter expert conformation.

Key captured information:

- EPRI, Continued SMART chemWORKS Development, Product ID: E223810, 26-Jul-2006
- Previous EPRI TI proposal for development of a plant data backbone standard
- Rolls-Royce Plant Care suite of software and analysis

Regulatory:
None.

Functional Areas:
CF-2 Administrative, CF-8 Chemical Analysis

Potential annual impact:
CF-2 will see a staff decrease of only a fractional FTE. The primary impact will be efficiencies in management reporting of and responding to data results, with the effect that data will become more effective as input to management in running the plant.

Other comments provided for perspective and insight for the next group working with this TDD

- EPRI chemistry monitoring and assessment data bases (third party use of chemistry and radiation monitoring information) provides a framework for system design.
- Data could be housed in an industry standard structure, with third-party access for specific, comparisons or reporting capabilities.

Proposed next steps:

- EPRI
  - Establish a project to evaluate data reduction, analysis, and reporting software platforms for chemistry and in-system radiological functions:
    - Existing software evaluation and determination of augmentation requirements, if any
    - Develop additional/modified software capability, as required.

TDD-RP3 Automated Personnel Monitoring and Dosimetry
Priority Rank: A

NOTE: This TDD provides the hardware backbone for:
TDD-RP-4: Automated ALARA Reviews and RWP Generation
TDD-RP-5: Automated Radiation Surveys and Dose Rate Calculations

Responsible Team:
TAG: Tim Tovar
SME: Phung Tran
EPRI Project: Kyle Turner

Technology and Design Details:
Real-time, automated (e.g., calibration), high reliability personnel monitoring and dosimetry capability, including;

- Remote monitor capability for visual observation of work and communication with personnel,
- Electronic reporting and documentation (e.g., electronic teledosimetry and shift log),
- Internal Positioning System (IPS) personnel and equipment location and mapping capability, and
- IPS-compatible, configuration controlled, three-dimensional (3D) plant model.

The system would be integrated across all units/modules and be compatible with off-site observation and management of personnel doing radiological work and associated dosimetry.

Development Needs:
Essential:

- Assess existing technology to determine scope of additional development effort necessary to achieve desired functionality
- Define interface requirements to integrate communications, monitoring, IPS, and dosimetry model into system with TDD-RP-3 functional capabilities, as described above.

Design Assumptions:

- Necessary portals and communications channels available for data monitoring, transmission and communications incorporated. Communications from plant areas that will use these capabilities are not obstructed by structures or other plant interferences.
- Support utilities for remotely deployed equipment (e.g., power).
- Systems and components incorporate a "plug and play" methodology to simplify evolving upgrades to local components and key system components.

Project Management/Construction Assumptions:
None.

Plant Operational Assumptions

- 3D plant model is maintained current and accurate to plant configuration.

Key captured information:

- EPRI, Remote Monitoring Technology Interim Report: Industry Best Practices and Lessons Learned, 2006, Product ID 1013508.
- Several EPRI central monitoring/remote monitoring reports containing Radiation Protection variables and references exist.

Regulatory:
Requires detailed review of SMR proposed and/or standard Technical Specifications to assure the proposed system can be used to its maximum capability and achieve the staffing intents.

Functional Areas:

- RPF-4 Dosimetry and Records Keeping
- RPF-7 Instrument Repair and Calibration
- RPF-9 Calibrate and maintain fixed instruments

Potential annual impact:
RPF-7 and RPF-9 will see a low increase (~2 FTE) due to increased number and complexity of monitors, RPF-4 will see a high decrease (~5 FTE) due to elimination of need for shift technicians and administrative personnel.

Other comments provided for perspective and insight for the next group working with this TDD

- Examine and take into account staff reduction synergies with TDD-RP-4 (Automated ALARA Reviews and RWP Generation) and TDD-RP-5 (Automated Radiation Surveys and Dose Rate Calculations).
- This TDD (RP 3) is the hardware backbone that enables TDD RP 4 and TDD RP 5.
- We did not assess the current state of the art of software or monitors to fulfill this need. Our experience leads us to believe that these capabilities can be achieved through assembly of existing technologies with upgrades as needed for this application.

Proposed next steps:

- SMR Vendors (possibly joint-vendor EPRI project)
  - Determine preliminary design configuration for remote monitoring/dosimetry system, including:
    - Evaluation of existing remote monitors and dosimetry algorithms for compatibility with integration into system.
    - Evaluation of existing, available IPS applications against nuclear plant needs.
    - Assess system communication approaches (e.g., wireless local area network, fiber optics) against environmental requirements, connectivity, bandwidth and cyber security requirements.
- EPRI
  - Review and update guidelines for personnel monitoring and dosimetry taking into account SMR design characteristics.
  - Develop conceptual system design requirements based on results of projects, above. Incorporate detail or by reference into the next pending revision of the EPRI URD.

TDD-RP4 Automated ALARA Job Reviews and RWP Generation
Priority Rank: A

NOTE: TDD-RP-3 provides the hardware backbone for this TDD and there is a high level of potential synergy between this TDD and both TDD-RP-3: Automated Personnel Monitoring and Dosimetry and TDD-RP-5: Automated Radiation Surveys and Dose Rate Calculations.

Responsible Team:
TAG: Tim Tovar
SME: Phung Tran
EPRI Project: Kyle Turner

Technology and Design Details:
Fully automated ALARA job reviews and RWP generation, including incorporation of information from operational experience and from electronic database developed from automated dosimetry and personnel monitoring systems (TDD-RP-3) and automated radiation surveys and dose calculations (TDD-RP-5).

Development Needs:
Enhanced:

- Standardized source term model, radiation field model, and dose model for SMRs.
- Model to use electronic dosimetry and monitoring data to feedback and update ongoing monitoring scope.
- Process for expanding module to track evolving requirements, fleet implementation, and extension to a larger population of plant data.

Essential:

- Assess existing database/analysis software packages to determine scope of additional development effort necessary to achieve desired functionality for ALARA reviews and generation of RWPs.
- Define interface requirements to integrate communications, monitoring, IPS, and dosimetry model into system with TDD-RP-4 functional capabilities, as described above.
- Develop algorithm/logic model for integrating information from operational experience, personnel monitoring, area surveys, fixed monitoring and dosimetry data into ALARA review for individual work plans and generation of RWPs.

Design Assumptions:

- Availability of electronic monitoring and dosimetry database, Internal Positioning System (IPS) personnel and equipment location and mapping capability, and IPS-compatible, configuration controlled, three-dimensional (3D) plant model.

Project Management/Construction Assumptions:
None.

Plant Operational Assumptions
None.

Key captured information:
- EPRI, Demonstration of Advanced 3D ALARA Planning Prototypes for Dose Reduction, Product ID:1025310

Regulatory:
- Additional technology development necessary before regulatory analysis.

Functional Areas:
- RPF-6 Exposure and Work Control
- RPF-21 Provide Radiological Job Coverage

Potential annual impact:
RPF-6 will see a high decrease (~5 FTE) due to reduction in need for work planners and radiation protection technicians; RPF-21 will see a low decrease (~2 FTE) due to more efficient deployment of radiation technicians for job coverage.

Other comments provided for perspective and insight for the next group working with this TDD
- TDD-RP-3 provides the hardware backbone that enables this TDD.
- Examine and take into account additional staff reduction synergies with TDD-RP-3 (Automated Personnel Monitoring and Dosimetry) and TDD-RP-5 (Automated Radiation Surveys and Dose Rate Calculations).
- We did not assess the current state of the art of software or algorithms to fulfill this need.

Proposed next steps:
- SMR Vendors (possibly joint-vendor EPRI project)
  - Review SMR designs to develop an envelope for operational and maintenance activities requiring ALARA reviews and RWPs.
  - Determine inputs (monitoring, survey and dosimetry) required to conduct ALARA reviews and write RWPs.

- EPRI
  - Assess existing database/analysis software packages to determine scope of additional development effort necessary to achieve desired functionality for ALARA reviews and generation of RWPs.
  - Develop algorithm/logic model for integrating information from personnel monitoring, area surveys, fixed monitoring and dosimetry data into ALARA review for individual work plans and generating RWPs.

TDD-RP-5 Automated Radiation Monitoring and Analysis
Priority Rank: A

NOTE: TDD-RP-3 provides the hardware backbone for this TDD and there is a high level of potential synergy between this TDD and both TDD-RP-3: Automated Personnel Monitoring and Dosimetry and TDD-RP-4: Automated ALARA Reviews and RWP Generation.

Responsible Team:
TAG: Tim Tovar
SME: Phung Tran
EPRI Project: Kyle Turner

Technology and Design Details:
Real-time, automated (e.g., calibration), high reliability capability for plant radiation monitoring and analysis, including:

- Area monitors and continuous air monitors and associated data feeds.
- Electronic analysis, reporting and documentation of monitoring results.
- Dose model and dose rate calculations.
- Reaction to emergency action level threshold values.

The system would be Integrated across all units/modules and be compatible with off-site observation and management of personnel doing radiological work and associated dosimetry.

Development Needs:
Enhanced:

- Standard radiation monitoring plan (e.g., frequency, locations, detector types) for SMRs.

Essential:

- Assess existing technology to determine scope of additional development effort necessary to achieve desired functionality.
- Define interface requirements to integrate data collection and analysis into system with TDD-RP-5 functional capabilities, as described above.

Design Assumptions:

- Necessary portals and communications channels available for data monitoring, transmission and communications incorporated. Communications from plant areas that will use these capabilities are not obstructed by structures or other plant interferences.
- Support utilities for remotely deployed equipment (e.g., power).
- Systems and components incorporate a “plug and play” methodology to simplify evolving upgrades to local components and key system components.
- System allows plant staff to establish emergency action level (EAL) threshold values and provides necessary EAL alerting and reporting functions.

Project Management/Construction Assumptions:
None.

Plant Operational Assumptions
None.

Key captured information:

- EPRI, 3D Radiation Field Estimation Algorithm v1.0, Product ID: 3002000032.

Regulatory:
Requires detailed review of SMR proposed and/or standard Technical Specifications to assure the proposed system can be used to its maximum capability and achieve the staffing intents.

Functional Areas:

RPF-7	Instrument Repair and Calibration
RPF-9	Calibrate and maintain fixed instruments
RPF-10	Calibrate and perform maintenance on fixed personnel monitoring equipment
RPF-11	Calibrate and perform maintenance on the air sampling equipment
RPF-14	Operate survey instruments
RPF-15	Operate Continuous Air Monitors (CAMs)
RPF-22	Perform remote monitoring operations

Potential annual impact:
RPF-7, RPF-9, RPF-10 and RPF-11 (combined) will see a low increase (~2 FTE) due to increased number and complexity of monitors; RPF-14, RPF-15 and RPF-22 (combined) will see a high decrease (~5 FTE) due to elimination of need for shift technicians and administrative personnel.

Other comments provided for perspective and insight for the next group working with this TDD

- Examine and take into account staff reduction synergies with TDD-RP-3 (Automated Personnel Monitoring and Dosimetry) and TDD-RP-4 (Automated ALARA Reviews and RWP Generation).
- TDD-RP-3 provides the hardware backbone that enables TDD-RP-4 and TDD-RP-5.
- We did not assess the current state of the art of software or monitors to fulfill this need. Our experience leads us to believe that these capabilities can be achieved through assembly of existing technologies with upgrades as needed for this application.

Proposed next steps:

- SMR Vendors (possibly joint-vendor EPRI project)
  - Determine preliminary design configuration for remote monitoring, dose modeling, and dose rate calculation system, including:
    - Evaluation of existing remote monitors and dose model algorithms for compatibility with integration into system.
    - Assess system communication approaches (e.g., wireless local area network, fiber optics) against environmental requirements, connectivity, bandwidth and cyber security requirements.
- EPRI
  - Review and update guidelines for area and air monitoring and dose calculation taking into account SMR design characteristics.
  - Develop conceptual system design requirements based on results of projects, above.
  - Incorporate detail or by reference into the next pending revision of the EPRI URD.

TDD-RP9 Automated Public Dose Assessment for EP
Priority Rank A

Responsible Team:
TAG: James Mallon
SME: Casey Carlson and Phung Tran
EPRI Project: Kyle Turner

Technology and Design Details:
Automated public dose assessment incorporating real-time, automated meteorological and radiation monitoring data for EP support during emergencies, with the objective of eliminating on-shift staffing driven solely by EP requirements (e.g., minimize need for roving monitoring teams).

Development Needs:
Essential:

- Software/hardware system capable of:
  - Accepting real-time meteorological and remote monitored radiation data.
  - Performing population dose calculations and projections in accordance with NRC-approved methods.
  - Reporting results continuously to emergency management personnel.
- Automated radiation monitors capable of remote monitoring and reporting of real-time radiation data.
- Secure, redundant communications system linking model servers, monitors and emergency response control centers.

Design Assumptions:

- Secure, dedicated communications channels among remote monitors, control room, emergency operations center.
- Remote monitors capable of avoiding damage or sustaining operation beyond challenge events (e.g., tampering, natural hazards) through design details, locations and/or numbers.
- Radiation monitors, dose model platform (e.g., servers), communications equipment and other required EP capabilities/functions remain operational, even given loss of power and/or natural hazard events during an emergency.

Project Management and Construction Assumptions:
None.

Plant Operational Assumptions:

- Plant EP plans assume normal on shift operators can provide all needed off site dose information during initial stages of an emergency condition.

Key captured information:

- Study linkages to the EPRI ANT EPZ efforts currently underway
- Consider insights and perspectives of the INPO EP Manager to focus on requirements
- SECY 15-0077 Option 1 EP regulations for SMRs

Regulatory:
The NEI White paper “Position Paper: Site Staffing for Small Reactors“ includes a regulatory analysis of potential SMR staff reductions for emergency response and states, in part, “Opportunities for optimizing staffing [at SMRs] need to address: Use of advanced technologies that help reduce emergency responder workloads.” The potential for TDD-RP-9 capabilities needs to be integrated into the on-going NEI EP initiatives.

Two NEI white papers exist related to SMR emergency planning and response:

- The “Reduce EPZ sizing” paper is entitled, “Proposed Methodology and Criteria for Establishing the Technical Basis for Small Modular Reactor Emergency Planning Zone,” and was submitted to the NRC in December of 2013, and
- The “Adjustments” paper is entitled, “Proposed Emergency Preparedness Framework for Small Modular Reactor Facilities.” This was submitted in July of 2015. The paper does provide proposed regulatory requirements for dose projections and field monitoring.

Functional Area:
RPF-27 RP Emergency Response

Potential staffing impact:
RPF-27 will see a high decrease (~5 FTE = 1 FTE /shift) based on elimination of need for shift technician staffing levels that are driven by EP (versus other operational) requirements.

Other comments provided for perspective and insight for the next group working with this TDD:

- We did not assess the current state of the art of software or monitors to fulfill this need. Our experience leads us to believe that these capabilities can be achieved through assembly of existing technologies with upgrades as needed for this application.
- Capability to assess ingestion exposure pathway zone impacts beyond what would be required by previously on shift staff where not considered.

Proposed next steps:

- NEI: Establish regulatory feasibility of and likely staff expectations for technology
- EPRI: Based on regulatory feedback, establish project to develop:
  - Dose modeling hardware/software system
  - Remote, automated radiation monitors
  - Secure communications infrastructure

TDD-M1 Standardized Components
Priority Rank: A

Responsible Team:
TAG – Erik Wagner
SME – Rick Way
EPRI Project – Kyle Turner

Technology and Design Details:
Reduce maintenance staff, number of qualifications and plant complexity by limiting the number of unique (type, make & model) components in plant design. This will enable a rapid remove-and-replace overall maintenance philosophy.

Development Needs:
Enhanced:
None.

Essential:
None.

Design Assumptions:
- Standardization of components will be implemented within an overall maintenance philosophy of rapid remove-and-replace;
  - Replacement components replicate those being replaced in fit, form, and function.
  - System/component mechanical, electrical and structural connections support rapid removal and replacement (i.e. rapid connections, flanged, minimize welding).
  - System/component mechanical and electrical isolation capabilities support rapid removal and replacement.
  - Large equipment subcomponents (e.g. large pump rotating element) should support rapid removal and replacement and full outsource to vendor if desired.
- Skid-mounted components will accommodate implementation of the component standardization approach.
- An emphasis is placed on selecting proven components.
- Engineering change processes will be simplified via supply chain pre-planning for equivalent changes.

Project Management and Construction Assumptions:
None.

Plant Operational Assumptions:
- On site and/or off site repair capability will exist to refurbish removed components and return them to ready storage for plant use.

- Plant staff will, when possible, procure replacement components consistent with the established standard components throughout plant life.
- The plant staff will take advantage of the following;
  - Time pressures, human error, unexpected degradation, parts unavailability and resultant plant impacts are reduced and/or eliminated.
  - Human error rates would be reduced via more repetition in and standardization of maintenance tasks.
  - Parts inventory will be reduced.
  - The complexity of plant documentation and record keeping will be reduced.
  - Component number reduction and standardization will foster the use of prototype-based training.

Key captured information:

- Limiting the number of and standardizing plant components is a well-established practice in the petrochemical industry (e.g., application at off-shore oil rigs has been aggressive).

Regulatory:

None.

Functional Areas:

Implementation of this TDD would provide potential staff reductions and efficiencies distributed across the maintenance functional areas listed below, by reducing the number of different component types and limiting the number of different practices and processes (and associated training) necessary to maintain plant equipment.

MF-1	Maintenance Training
MF-3	Job Scoping, Troubleshooting and Walkdown
MF-4	Work Package Implementation
MF-5	Corrective Maintenance
MF-6	Preventive Maintenance
MF-8	Tools and Instruments
MF-9	Warehousing
MF-10	Equipment Monitoring

Implementation of the TDD would also reduce inventory costs by reducing the total number of components that must be procured and warehoused. Additional staffing reductions in engineering, operations and other disciplines could also result from TDD implementation.

Potential staffing annual impact:

Maintenance would see a large overall decrease in staffing (>10 FTE), including training and warehousing staff. Additional cost savings associated with reduced replacement component inventory would also be realized.

Other comments provided for perspective and insight for the next group working with this TDD:

- Expectation is that this approach will also reduce error rates and simplify overall maintenance.
- Proven components should be selected for standardized applications.
- Implementation would involve picking one type of component (e.g., AOV) and using it in as many applications as possible, thereby limiting the number of models of a given component in the plant.
- Implementation would require going back to the same vendor(s) to procure standardized parts; there could be an impact to the ability to competitively bid for replacement components.
- Component repair will mimic the US Navy's maintenance approach, with repeatability in plant models and the ability to maintain one storage location that can service many stations and allow for more "rapid remove-and-replace" maintenance with refurbishment occurring at a main repair facility.
- Requirements for establishing long term supply chain viability should be considered.

Proposed next steps:

- This TDD approach and its benefits are currently available for SMR project implementation.

TDD-M2 Cross-Training of Maintenance Staff
Priority Rank: B

Responsible Team:
TAG: Greg Ruppert
SME: Richard Pepin
EPRI Project: Kyle Turner

Technology and Design Details:
Use of multi-skilled personnel for maintenance functions, inspection functions, radiation protection functions and some engineering functions. Craft will be experienced (including non-licensed operators) and cross-qualified in various aspects of mechanical, electrical and instrumentation maintenance tasks.

Development Needs:
<u>Enhanced:</u>
None.

<u>Essential:</u>
- Review and assemble existing qualification requirements to develop qualification sets for multi-skilled supervisors and craft. Such review will use SAT (Systematic Approach to Training) principles to establish “qualification sets”.
- Revision of INPO ACAD program, as necessary, to reflect multi-skill qualification of personnel.

Design Assumptions:
- Design embraces the standard component philosophy and rapid remove-and-replace functionality outlined in TDD-M-1.
- Design embraces the connectivity capabilities outlined in TDD-M3.

Project Management and Construction Assumptions:
None.

Plant Operational Assumptions
- Large, labor intensive or detailed overhauls would be performed by OEM/Vendors onsite or offsite with much of maintenance being “remove-and-replace”.
- Modular/repeatable design allows for mock-up training of teams at a central location much like prototype training.
- Complex modifications that complicate the cross training approach will be avoided.

Key captured information:

- EPRI Task Proficiency Qualification testing data bank and instructions EPRI Plant Engineering Program.
- EPRI Engineering Technical Training Modules (ETTM) EPRI Plant Engineering Program

Regulatory:
NEI 06-13A, related NRC documents and INPO ACAD expectations must be reviewed and revised to reflect cross discipline training and qualification.

Functional Areas:
Implementation of this TDD would provide potential staff reductions distributed across the maintenance functional areas listed below, by expanding capabilities of individual staff members, so that additional personnel trained only to a single maintenance expertise are not necessary to maintain plant equipment.

MF-1 Maintenance Training
MF-2 Work Planning and Scheduling
MF-4 Work Package Implementation
MF-5 Corrective Maintenance
MF-6 Preventive Maintenance
MF-10 Equipment Monitoring

Potential staffing annual impact:
Maintenance would see a large overall decrease in staffing (greater than 10 FTE) across mechanical, electrical and instrumentation/controls maintenance staff. Additional, small (<5 FTE) reductions in work planning, radiation protection, quality control and operations staff would also be realized.

Other comments provided for perspective and insight for the next group working with this TDD:

- Component repair will mimic the US Navy's maintenance approach, with repeatability in plant models and the ability to maintain one storage location that can service many stations and allow for more "rapid remove-and-replace" maintenance with refurbishment occurring at a main repair facility.
- The INPO ACAD program must be taken into account in designing the cross-training approach.
- Individual plant operators will need to address plant-specific union issues related to implementing cross-training for craft work.
- It is noted that many functions within the plant can benefit from cross training. Although this TDD addresses Maintenance, it should be read to include other plant cross training opportunities as well.

Proposed next steps:

- EPRI
  - Initial a project to review existing qualification requirements and industry maintenance practices to develop guidance on qualification sets for multiskilled supervisors and craft.
- NEI
  - Incorporate the capabilities of this TDD into the evolving standard technical specifications and design specifications for SMRs.
- INPO
  - Review INPO ACAD expectations to determine actions necessary to reflect cross training qualifications and training.

TDD-M3 Connectivity
Priority Rank: A

Responsible Team:
TAG: Spencer Semmes
SME: Joe Naser, Rick Pepin
EPRI Project: Kyle Turner

Technology and Design Details:
Maintain a central repository database of plant/plant component and training/qualification information with associated analysis and reporting capability. Install wireless communications capability for 100% coverage during build to allow staff access to central plant database throughout plant life. Choose an Enterprise Asset Management (EAM) System with specifications that will enable and ensure: tablet use in field, automated training verification, parts tracking, re-order and re-stocking, automated update to scheduling tool (i.e. Primavera), procedure validation and current-version availability, compiled component information, clearance sign-on, operations approval, as-found and as-left entry, real-time revision capability, worker tracking, trouble-shooting information, interaction with SMEs on and off job site, and plant logs. Use of the above processes will allow reductions in warehouse, training, planning, operations and work management staff.

Development Needs:
<u>Enhanced:</u>
- Determine all needed information and analysis capability necessary to support end-user tasks.

<u>Essential:</u>
None.

Design Assumptions:
- System will be implemented as holistic design element throughout project development.
- Interference between system and other digital control equipment will be prevented.
- System will be capable of communication with on- and off-site SMEs, with appropriate controls for data access applying to offsite personnel accessing the database.
- Installed components ("smart" instruments and equipment) will talk through data net (out only) and will include other "smart" functions, such as self-checking, calibration, diagnostics, and analysis across multiple instruments to obtain "best value" results, as appropriate.
- Access to all plant and component design data will be provided. This includes issued drawings, vendor documents and maintenance manuals.
- System should be easily configurable for multiple users, so that each owner can implement different levels of approval or verification at different process steps, as required.
- System will be configured to interface from a robust mobile platform and to access data and documents in a simplified manner (versus document storage systems that require large monitors).

Project Management and Construction Assumptions:
None.

Plant Operational Assumptions

- System is implemented based on data-centric information management (versus document-based).
- System data are kept current with plant configuration and will provide users with a conformed copy or direct access to the Appendix B configuration controlled plant data repository, so that real time access to current, approved documentation is available.

Key captured information:

- EPRI NMAC project Use of LTE Cellular Network and Distributed Antenna Systems to Improve Connectivity and Increase Data Transfer should receive strong consideration.
- EPRI guidelines:
  - Improving the Execution and Productivity of Maintenance with Electronic Work Packages: A Mobile Work Management Initiative; EPRI 03002005363
  - Electronic Collection of As-Found Component Condition Data; EPRI 03002004690
  - Program on Technology Innovation: Machine Verification in Laser-Scanned Spaces—Status Update 1; EPRI 03002003062
  - Advanced Nuclear Technology: Data-Centric Configuration Management for Efficiency and Cost Reduction: An Economic Basis for Implementation; EPRI 03002003126
  - Computerized Procedure Systems: Guidance on Design, Implementation and Use of Computerized Procedure Systems, Associated Automation and Soft Controls; EPRI 1015313, August 2010.
- Exelon and FP&L are currently in the process of implementing similar connectivity capabilities at some of their plants.

Regulatory:
Resolution of regulatory concerns on interference with digital control systems. For example, validation of interaction (lack of potential interference) with other plant digital equipment (i.e., digital control systems) will be required by NRC.

Functional Areas:

MF-1 Maintenance Training
MF-2 Work Planning and Scheduling
MF-4 Work Package Implementation
MF-9 Warehousing

Potential staffing annual impact:
Overall, maintenance would see a notable (>5 FTE) decrease in staff, with a rough distribution of 1 FTE in each of the functional areas listed above plus craft time savings on each job.

Other comments provided for perspective and insight for the next group working with this TDD:

- Sample processes that demonstrate analogous functionality to that anticipated in this TDD:
  - Boeing remote engine monitoring, reporting and analysis.
  - Petroleum industry – Staff optimization on and remote support for oil rigs
  - OECD Halden Reactor Project, Integrated Operations Program
  - Rolls-Royce Plant Care program.
- An accurate 3-D model of the plant must be provided as part of the vendor's design and confirmed or raised to as-built status by the EPC. A 3-D scan of the completed plant may be necessary for the latter.
- In addition to staff savings, implementation of this TDD will provide reduction of errors (e.g., working on wrong equipment) and job documentation cost, as well as improving plant status.

Proposed next steps:

- SMR Vendors
  - This TDD is considered available for SMR project teams to incorporate into their designs.
- EPRI
  - Continue work on definition of end user needs.
  - Continue work on NMAC "leaky cable" technology for nuclear applications.

TDD-M4 Automated Electronic Mobile Work Management
Priority Rank: A

Responsible Team:
TAG: Spence Semmes
SME: Rick Pepin
EPRI Project: Kyle Turner

Technology and Design Details:
Implement an automated, electronic, work management/planning system that incorporates wireless technology. Processes should include standard work orders, real time revision and approval capability, and worker tracking. The system would be linked with the work management planning system (e.g., Maximo software) and to the plant data repository and/or central digital data repository (TDD-M3).

Development Needs:
Enhanced:
None.

Essential:
None.

Design Assumptions:
- Output formats are reactor technology specific and may be developed through an owner's group.
- Design incorporates the connectivity functionality outlined in TDD-M3.
- Interference between system and digital control equipment will be prevented. System will be interconnected with the plant master schedule.
- System will be capable of validating procedures and training, real-time during work planning and execution, including job scoping and job site preparation needs.
- Output formats should be easily user configurable to address individual operator output or approval formats.

Project Management and Construction Assumptions:
None.

Plant Operational Assumptions
- System is used to full capability by plant staff.

Key captured information:
- EPRI guidelines:
  - Improving the Execution and Productivity of Maintenance with Electronic Work Packages: A Mobile Work Management Initiative; EPRI 03002005363

Regulatory:

- Definition of and resolution of regulatory concerns on interference with digital control systems. For example, validation of interaction (lack of potential interference) with other plant digital equipment (i.e., digital control systems) will be required by NRC.

Functional Areas:

MF-2 Work Planning and Scheduling
MF-3 Job Scoping, Troubleshooting and Walk-down
MF-4 Work Package Implementation

Potential staffing annual impact:

Overall, maintenance would see a medium (3 - 7 FTE) decrease in staff across the functional areas listed above.

Other comments provided for perspective and insight for the next group working with this TDD:

- Choose an Enterprise Asset Management (EAM) System with specifications that will enable and ensure: tablet use in field, automated training verification, parts tracking, re-order and re-stocking, automated update to scheduling tool (i.e. Primavera), procedure validation, clearance sign-on, operations approval, as- found and as- left entry, real time revision capability and worker tracking. The use of the above processes will allow less warehouse, training, planning, operations and work management staff.

Proposed next steps:

- SMR Vendors
  - This TDD is considered available for SMR project teams to incorporate into their designs
- EPRI
  - Continue mobile work management (mWM) development
  - Initiate project in cooperation with SMR vendors to develop standards ensuring compatibility of system with digital controls elsewhere in the design.

TDD-M5 Design for Maintenance Effectiveness and Efficiency
Priority Rank: C

Responsible Team:
TAG – Erik Wagner
SME – Rick Way
EPRI Project – Kyle Turner

Technology and Design Details:
Concurrent consideration for maintenance/replacement needs during all stages of plant design evolution to optimize maintainability and facilitate component replacement throughout plant life.

Development Needs:
<u>Enhanced</u>
None

<u>Essential</u>
None

Design Assumptions:
- Maintainability should be considered at all design reviews and key stages. These questions should be asked: Can the maintenance task be eliminated by design? Can it be simplified by design? Can it be enabled by design? Can it be performed less frequently by design?
- Provisions included to enable simplification and enable maintenance should be captured in the design basis documents so they can be sustained by the operating staff.
- Every plant component will require replacement sometime in the life of the plant.
- The concept of standardization of components as described in TDD-M1 should be embraced, including enabling a rapid remove-and-replace overall maintenance philosophy.

Project Management and Construction Assumptions:
- Design provisions for maintainability will be preserved throughout construction, e.g., design changes during construction will be reviewed with the same questions as outlined under Design Assumptions, above.

Plant Operational Assumptions:
- Design provisions for maintainability will be preserved through any plant changes, e.g., they will be reviewed with the same questions as listed under Design Assumptions, above.

Key captured information:

- Use of maintenance experienced persons during early design reviews to ask specific maintenance critical questions can be very valuable to the design team. See EPRI reports for examples:
  - EPRI NMAC Maintainability Review of the Pebble Bed Modular Reactor Demonstration Plant; EPRI 1003386
  - EPRI NMAC Maintainability Review of the International Gas Turbine Modular Helium Reactor Power Conversion Unit; EPRI 1001231

Regulatory:
None.

Functional Areas:

MF-5 Corrective Maintenance
MF-6 Preventive Maintenance

Potential staffing annual impact:
MF-5 and MF-6 would see a low (<5 FTE across the two functional areas combined) reduction in base plant staff. Additional, more significant savings will result from efficiencies gained during major plant maintenance, e.g., large component replacement, refueling outages.

Other comments provided for perspective and insight for the next group working with this TDD:

- The greatest benefit is realized by eliminating significant project/plant errors and problems before they become hardware.
- Considerations included in maintainability input to design should include:
  - Availability of self-monitoring equipment
  - Automated maintenance capability
  - Work sequencing and work planning
  - Access
  - Equipment/component service life, replacement projections and frequency
  - Preventive maintenance cycle for individual components
  - Low frequency but high consequence maintenance situations.

Proposed next steps:

- SMR Vendors
  - This TDD is considered available for SMR project teams to incorporate into their designs.

TDD-E1 Engineering Tools
Priority Rank: B

Responsible Team:
TAG – Spence Semmes
SME – Leonard Loflin, Joe Naser
EPRI Project – Kyle Turner

Technology and Design Details:
Integrated suite of cross-functional technical tools that is interoperable with the plant CMIS (Configuration Management Information System) that will assure that the owner/operator of the plant maintains to the extent practical and realistic the engineering tool set used by the EPC contractor during plant development. This capability will enable cross-checking of design details of various disciplines during the original design and design change processes. The suite would be a data-centric system maintained from design through operations. It would provide a functional tool for plant design engineering and a reference tool for the remainder of plant staff. It would use a "single source of truth" concept where each item is stored once and used across the design assuring that all design cases have fidelity.

Development Needs:
<u>Enhanced:</u>
Examine feasibility and cost-benefit of upgrading system documentation (validation & verification [V&V]) to allow full Appendix B qualification and eliminate the need for manual verification of outputs.

<u>Essential</u>
None.

Design Assumptions:
- Existence of up-to-date 3D plant model accurate to necessary design engineering tolerances (TDD-M3).
- Software package used by design engineer and constructor should be forward-compatible to the package used by the owner/operator.
- The design of the capability will encompass aspects of design and configuration control essential for post operation plant changes which may not be required for original design (i.e. interaction with plant procedures, support of plant procurement activities).
- The capability should be created with the understanding that software packages available for data control and analytics will be constantly improving. To the extent practical, the ability to embrace new and upgraded capabilities should be a fundamental assumption of the design of this capability. For example, the structure will accommodate enhanced engineering technical and analytical tools as they become available.
- The engineering tool platform should have the capability to interact with third-party analytical and design software to assure data transfer for future and current analytical needs.

- The engineering tool set should be capable of being tied to the plant asset management and work planning systems to assure that the "single source of truth" for plant design data concept transfers data accurately and quickly to each of the other systems.
- The tool set would be based on a functional 3D model (TDD-M3) that incorporates elements necessary for design, for example, instrument tubing, pipe and tubing supports, cable tray loading and electrical cable design. (This will allow, for example, that recalculations of cable voltage drop and pipe hanger loading and design are quickly validated using the original tools that the EPC contractor used).

Project Management and Construction Assumptions:

- EPC contractor will provide the as-built plant model data as a contract deliverable in a form compatible with the requirements of the CMIS package used by the owner/operator.
- The contractor turnover package will include the entire data package (i.e., all necessary design data to modify and operate the plant).

Plant Operational Assumptions:

- Operator maintains the underlying plant model data current to actual plant configuration.
- Plant procedures and programs are structured to feed from and feed into the CMIS in a seamless manner.
- The plant Owner maintains the right and ability to make changes as needed and justified for their plant within and outside of the boundary of the Standardized Plant.

Key captured information:

- Examples of existing software platforms with functionality to implement this TDD are SmartPlant® (Intergraph) and CATIA (Dassault).
- The U.S. Navy uses similar systems to accomplish submarine design and fabrication at 2 different yards interactively, with central assembly under close tolerance requirements.

Regulatory:
None.

Functional Areas:
Implementation of this TDD would provide potential staff reductions and efficiencies distributed across the engineering functional areas listed below, by improving the ability to access, analyze, use and communicate plant engineering information and by automating design processes, where possible.

EF-1	Engineering Change Process
EF-3	Procurement Requisition Process
EF- 4	Plant Modifications
EF-5	ERO EOF Technical Support Engineer
EF-11	System Engineering/Monitoring
EF-12	Component Engineering/Troubleshooting

Potential staffing annual impact:
If implemented, Engineering would see a large overall decrease in staffing (>10 FTE) through implementation of a fully functional non Appendix B version. Having a qualified Appendix B version will further decrease engineering staffing

Other comments provided for perspective and insight for the next group working with this TDD:

- Current applications of such plant models are not qualified to 10 CFR 50 Appendix B requirements; outputs require manual V&V. Additional model V&V will be required to eliminate the human review function, with corresponding staff reductions.
- Each SMR design will have an "off-the-shelf" STANDARDIZED scope boundary. In addition, the NRC will approve a standard design that will be encompassed in the product purchased from the SMR vendor, also having a scope boundary. Any changes and/or modifications will need to be understood on how it effects each scope boundary and reflected in the FSAR. This product could be set up to both visually and technically help maintain those boundaries.
- The positive impacts of this TDD are increased under a fleet-based program engineering model.

Proposed next steps:

- SMR Vendors
  - This TDD approach and its benefits are currently available for SMR project implementation, but with the caveat that – absent software quality assurance upgrades – manual V&V of design products will be required.
- EPRI
  - Investigate the effort necessary to upgrade existing design management software to Appendix B standards; develop guidelines for use, as applicable.

TDD-E2 Automated Plant Health Management System Assuring Plant and Equipment Reliability
Priority Rank: A

Responsible Team:
TAG – Rick Way
SME – Rick Way/Leonard Loflin
EPRI Project – Kyle Turner

Technology and Design Details:
Automated system using plant connectivity established under TDD M3 to provide automated monitoring and analysis of component and system performance data, sufficient to satisfy plant health monitoring and reporting requirements. This capability will also provide plant system health information needed to assure plant and equipment reliability (e.g., pump vibrational data and bearing temperatures). System includes automated troubleshooting that incorporates known system and component troubleshooting and failure mode information as well as more sophisticated analysis and evaluations, such as comparison of performance data to norms, such as pump curves or trend information.

Development Needs:
<u>Enhanced:</u>

- Continued development of prognostics capability for plant components and systems. As a minimum, continued progress and achievement by the EPRI programs noted in "Key Captured Information" later in this TDD.
- Enhanced capability for cross-plant (e.g., fleet management) data analysis and comparison

<u>Essential</u>

- None

Design Assumptions:

- Plant parameters and requirements necessary to support an automated plant health monitoring system are incorporated into facility design basis and component specifications.
- Plant designers, component suppliers and EPC contractors incorporate necessary design details and process specifics to assure a sustained high level of component and plant reliability. See related EPRI products listed under "Key Captured Information" later in this TDD.
- Plant designers, component suppliers and EPC contractors provide to plant operator necessary component design, system design and baseline information to enable prognostic analysis of performance data.
- This system will support and use documentation of as-found/as-left conditions during maintenance and modifications. The ability to recommend changes to preventive maintenance requirements will be incorporated.

Project Management and Construction Assumptions:

- Construction, storage and testing processes protect plant equipment to preserve its capability to operate reliably as designed. See related EPRI products listed under "Key Captured Information" later in this TDD.

Plant Operational Assumptions:

- Plant processes maintain the integrity of the underlying system and component data so that the output of the Health Management System is decision quality.

Key captured information:

- Ongoing EPRI project: Fleet-wide Prognostic Health Monitoring (tools exist; data is being assembled)
- Equipment Reliability Working Group has a standard for plant health reporting
- EPRI Operates a Fleet-wide Monitoring Interest Group
- EPRI reports critical to this TDD
  - EPRI Preventive Maintenance Database version 3.1 web based at pmdb.epri.com
  - Equipment Reliability for New Nuclear Plants; Industry Recommendations for Design; EPRI 1021415
  - Equipment Reliability for New Nuclear Plants; Industry Recommendations for Procurement; EPRI 1021416
  - Equipment Reliability for New Nuclear Plants; Industry Recommendations for Storage, Construction and Testing; EPRI 1021413

Regulatory:
None.

Functional Areas:
Implementation of this TDD would provide potential staff reductions and efficiencies distributed across the engineering functional areas listed below, by streamlining the engineering and documentation processes that support plant health monitoring and analysis. Maintenance staff reductions could be significant through reduction and simplification of preventive maintenance work and related planning and work preparation

EF-9	Corrective Action Process
EF-11	System Engineering/Monitoring
EF-12	Component Engineering/Troubleshooting
MF-6	Preventive Maintenance

Potential staffing annual impact:
Engineering would see a limited (≤ 5 FTE) overall decrease in staffing. However, achieving high levels of plant reliability while containing maintenance cost (reduced number and content of preventive maintenance tasks) should be expected and could be significant (potentially ≥10 FTE).

Other comments provided for perspective and insight for the next group working with this TDD:

- The purpose of a plant health management system is to assure component reliability is high and plant reliability is high.
- Data sets (such as instrumentation calibration frequencies) produced by the Plant Health Management System may support regulatory relief for, e.g., technical specification changes.
- The positive impacts of this TDD are increased under a fleet-based program engineering model.

Proposed next steps:

- SMR Vendors
  - This TDD approach and its benefits are currently available for SMR project implementation.
- EPRI
  - Ensure fleet-wide prognostic health monitoring project addresses SMR-specific design considerations.

TDD-E3 Program Engineering Automation
Priority Rank: A

Responsible Team:
TAG – Spence Semmes
SME – Rick Pepin
EPRI Project – Kyle Turner

Technology and Design Details:
Incorporation of component and system instrumentation necessary for collection of, automated analysis of, and reporting of monitored data for components and systems subject to mandatory program requirements (e.g., motor-operated valves [MOV], air-operated valves [AOV], check valves, heat exchangers, pump performance).

Development Needs:
Enhanced:
- Cost effective inline oil analysis for component status
- Cost effective Check Valve testing

Essential:
None.

Design Assumptions:
- Implementation of component reduction and standardization as defined in TDD M1.
- Sensor accuracy meets code requirements and standards as needed for each component covered by a given program.
- System design allows for program-required operational testing.
- The design agent and potential owners have agreed on the list of mandatory programs that must be encompassed. Mandatory may include programs beyond NRC requirements (e.g. environmental, OSHA)

Project Management and Construction Assumptions:
- System and component baseline data necessary to populate and enable this capability will be compiled. Such compiled data will populated in the necessary automated systems created to support the Program Engineering Automation capability.

Plant Operational Assumptions:
- Instrumentation, analytics, data and reporting capabilities will be maintained to the quality standards necessary for generating automated system health reports and supporting information to demonstrate compliance with technical specifications and other program requirements.

Key captured information:

- EPRI NMAC project - Use of LTE Cellular Network and Distributed Antenna Systems to Improve Connectivity and Increase Data Transfer
- Local leak rate testing monitoring capability; (AREVA FLUS System) (http://de.areva.com/EN/customer-591/flues-leakage-monitoring-for-components-and-equipment-compartments.html)
- EPRI report "Intelligent Plant Configuration Management Using Wireless Sensors: Application to Nuclear Power Plant Valves", 3002005325, July 2015, addresses instrumenting valves so that the actual position can be measured. The valve position is sent wirelessly to display the current position and into a database of current configuration. The work was done at INL and Idaho State University, by modifying their existing flow loop to include more flow paths and additional valves. Videos of the scenarios tested are included in the report.

Regulatory:
None.

Functional Areas:
Implementation of this TDD would provide potential staff reductions and efficiencies distributed across the engineering functional areas listed below, by automating the component performance data collection and analysis for components covered by regulatory-required programs.

EF-6	Program Management
EF-11	System Engineering/Monitoring
EF-12	Component Engineering/Troubleshooting

Potential staffing annual impact:
Engineering would see a large (≥ 5 FTE) overall decrease in staffing.

Other comments provided for perspective and insight for the next group working with this TDD:

- Assuring that intended end state reports meet the requirements of each receiving government and/or code organization is critical for this TDD to be successful.
- The positive impacts of this TDD are increased under a fleet-based program engineering model.

Proposed next steps:

- SMR Vendors
  - This TDD is considered available for SMR project teams to incorporate into their designs.
- EPRI
  - Initiate project to examine cost-effectiveness and development requirements for:
    - Cost effective inline oil analysis for component status
    - Check valve testing

TDD-O1 Intelligent Configuration Management Optimization
Priority Rank: A

Responsible Team:
TAG – Farshid Shahrokhi
SME – Lee Catalfomo
EPRI Project – Leonard Loflin

Technology and Design Details:
Install technical capabilities and plant 3D models allowing determination of the physical status of plant configuration at any time. This results in minimizing the need for field verifications and for operators to physically go to specific locations confirming status of components. This capability must address operational workload associated with outages and outage recovery, as well as other major changes of plant condition. Portions of the plant infrequently changed may not require this capability. All associated information must be decision quality.

Development Needs:
<u>Enhanced:</u>
- A scoping study to identify which components are best verified by 3D scans and which are best verified by “smart components” will accelerate the use of this concept.
- Simplified concepts to determine condition/position of lower voltage (240v and 120v) electrical circuits are needed. Uncertain reliability of molded case circuit breakers complicates this determination.
- Examine feasibility and cost-benefit of upgrading system documentation (validation & verification [V&V]) to allow full Appendix B qualification of plant status configuration model. This is important for full benefit of this TDD.

<u>Essential:</u>
- Requirements to accomplish spatial position determination are still under development and must be completed [ongoing EPRI project - Machine Verification in Laser-Scanned Spaces - Status Update 2 Product ID: 3002005521]

Design Assumptions:
- Minimizing the number and type of plant components increases the reliability and use of this capability (see TDD M1).
- Provides real time automated updates to plant configuration management systems such as eSOMS (Electronic Shift Operations Management System)
- Need for manual valves is to be minimized; ease of access and line of sight orientation are required.
- Where critical, the ability to transmit out component status is to be incorporated.
- Bar coding, radio frequency tagging and/or other unique component/equipment identification (connectable) identification technology is included where needed.

- Structural supports (pipe hangers, seismic restraints, cable tray supports, etc.) do not impede this capability.

Project Management and Construction Assumptions:
- Field run and supported conduit, tubing and/or small bore piping in safety and non-safety plant areas must not impede this capability.

Plant Operational Assumptions:
- 3D plant model is maintained current and accurate to plant configuration.

Key captured information:
- Machine Verification in Laser-Scanned Spaces - Status Update 1; EPRI 3002003062.
- Machine Verification in Laser-Scanned Spaces - Status Update 2; EPRI 3002005521.
- EPRI report "Intelligent Plant Configuration Management Using Wireless Sensors: Application to Nuclear Power Plant Valves", 3002005325, July 2015, addresses instrumenting valves so that the actual position can be measured. The valve position is sent wirelessly to display the current position and into a database of current configuration. The work was done at INL and Idaho State University, by modifying their existing flow loop to include more flow paths and additional valves. Videos of the scenarios tested are included in the report.

Regulatory:
None

Functional Areas:
Implementation of this TDD would provide potential staff reductions and efficiencies distributed across the operations functional areas listed below, by improving the ability to access, analyze, use and communicate plant configuration information.

OP-1	Plant Configuration Control (includes system lineup)
OP-4	Work Control (Clearance and Tagging)
OP-5	Testing (Surveillance, ASME Code, Post Maintenance, Post Modification)
OP-6	Preventative Maintenance
OP-7	Operations Logs
OP-9	Outage Support

Potential staffing annual impact:
Operations would see a large (~10 FTE) decrease in staffing across all shifts through implementation of this TDD.

Other comments provided for perspective and insight for the next group working with this TDD:

- Level of impact on Maintenance workload and staffing level were not determined but should be determined.
- Current applications of such plant models are not qualified to 10 CFR 50 Appendix B requirements; outputs require manual V&V. Additional model V&V will be required to eliminate the human review function, with corresponding staff reductions. This is important for full benefit of this TDD.

Proposed next steps:

- EPRI
  - Investigate the status and capabilities of existing systems for providing adequate location and position information on components and equipment that will need to be included in the plant status data base.
  - Complete – Program on Technology Innovation: Machine Verification in Laser-Scanned Spaces.
  - Investigate the effort necessary to upgrade existing design management software to Appendix B standards; develop guidelines for use, as applicable.
- Vendors
  - Proceed to implement to the extent practical.

TDD O2 Automation of monitoring, analysis, operational functions including Electronic Procedures
Priority Rank: B

Responsible Team:
TAG – Tim Tovar
SME – Joe Naser
EPRI Project – Leonard Loflin

Technology and Design Details:
Necessary integration and automation of plant information to support Operation's needs to monitor and analyze plant data to allow enhanced plant automated functions, the effective use of electronic procedures and automation of plant logs including narrative entries. This capability will provide support under normal and abnormal plant conditions. Is assumed to be accessible to, usable by and where necessary used to support Engineering, Maintenance and other plant monitoring and analysis capabilities. Wireless transmission of data enhances this capability.

This capability embraces:
- Monitoring and analysis
- Computer based procedures with automated actions
- Automatic logs
- Intelligent alarm system

Development Needs:
<u>Enhanced:</u>
- Perspective on the optimal use of this capability to diagnosis basic plant conditions allowing this capability to recommend and/or to enter specific plant procedures is needed. Similar perspective is needed to determine optimal use of this capability to perform automatic operations independent from the operator but with oversight by the operator.

<u>Essential:</u>
- Intelligent alarm system applying logic, prioritization and suppression (this is a high want). A standard perspective and process for what such a system would embrace is needed. A methodology needs to be developed that allows multiple suppliers and users to achieve the desired standard. Regulatory perspective must to be considered.

  Although individual designers could pursue "intelligent alarm systems", true industry success in this area requires industry and regulatory agreements on approaches and standards. An example of these standards would be treatment of failure tolerance – absorbing system failures while continuing seamless operations.

Design Assumptions:

- This is assumed to be a Type 3 system per IEEE 1786.
- This capability addresses both in control room and out of control room operations.
- This capability is supported by some level of intelligent plant configuration management as detailed in TDD O1.
- Provide information display design techniques for identifying required information and displaying the information in a form, based on the decision(s) task(s) required, that facilitate rapid situation awareness and decision-making in order to oversee automation or to play the appropriate role in shared human-automation tasks.

Project Management and Construction Assumptions:

None.

Plant Operational Assumptions:

- System is implemented based on data-centric information management (versus document-based).
- System data are kept current with plant configuration and will provide users with a conformed copy or direct access to the Appendix B configuration controlled plant data repository, so that real time access to current, approved documentation is available.

Key captured information:

- EPRI report - Human Factors Guidance for Control Room and Digital Human-System Interface Design and Modification: Guidelines for Planning, Specification, Design, Licensing, Implementation, Training, Operation, and Maintenance for Operating Plants and New Builds, Product ID 3002004310, December 2015.
- EPRI report - Program on Technology Innovation: Decision-Centered Guidelines for the Design of Human System Interfaces for Electric Power Industry Applications: Design Guidance to Support Decision Making in Complex Work Environments, Product ID 1025791, September 2012. (this is a very relevant report for this capability)
- IEEE Guide for Human Factors Applications of Computerized Operating Procedure Systems (COPS) at Nuclear Power Generating Stations and Other Nuclear Facilities (IEEE Std 1786-2011), June 2011
- BNL-NUREG-67216 Computerization of Nuclear Power Plant Emergency Operating Procedures

Regulatory:

- Need resolution of the paper backup (minimize and/or eliminate and/or other alternatives) requirement for electronic procedures.

Functional Areas:

- Implementation of this TDD would affect plan Operations staffing in the following areas.

  OP-1 Plant Configuration Control (includes system lineup)
  OP-2 Plant Operations (Normal, Abnormal, Emergency, BDBE, SA, Refueling, Start up, Radwaste, Switchyard)
  OP-3 Operations Training (includes all required training)
  OP-4 Work Control (includes Clearance & Tagging, work package review, work authorization, scheduling, etc.)
  OP-8 Operations Procedure Review & approval
  OP-23 Operations Qualifications

Potential staffing annual impact:
Overall, operations would see a high (~10 FTE) decrease in staff across the functional areas listed, with a concentration of savings in OP-3, OP-4 and OP-8. Additional staff savings in engineering and maintenance would also accrue from TDD implementation.

Other comments provided for perspective and insight for the next group working with this TDD:

- Intelligent alarms system is essential to get the staffing and effectiveness desired.
- NEI and EPRI should work in concert to achieve the necessary perspectives and standards for intelligent alarm systems to be designed and implemented.
- It is critical that design teams involve operators to effectively implement these concepts.
- Identification of correct information in the correct form for automation system and associated human interactions based on the task(s) to be done or decision(s) to be made is necessary.

Proposed next steps:

- NEI
  - Pulse NRC staff for initial positions on use of an intelligent alarm system. In conjunction with EPRI project below, develop industry position for regulatory approach.
- EPRI
  - Investigate and develop hardware/software system designs to achieve an intelligent alarm system applying logic, prioritization and suppression. The methodology should allow multiple users to achieve the desired functionality.
  - Develop a standard for what such a system would embrace. Support regulatory interface to achieve staff acceptance.
  - Investigate and expand appropriate approaches for automation, including procedures and support systems, and the appropriate human-system interaction roles.

TDD-T1 Use of Advanced, Technology-Based Training Methods
Priority Rank: A

Responsible Team:
TAG – Cristina Corrales-Quiros
SME – Lee Catalfomo, Tom Giebelhausen
EPRI Project – Leonard Loflin

Technology and Design Details:
Utilize advanced training techniques (e.g., augmented and virtual reality, serious games, self-training and e-learning capabilities, mock ups, 3D Component Training aides) to reduce plant staff time and training resources required to achieve training objectives and to deliver training (e.g., physical simulator and instructor time). This includes reducing both the absolute time and the calendar duration required to achieve training.

Development Needs:
Enhanced:
Create of menu of information on technology options, software platforms and approaches for use by SMR design community in developing training content. Build-forward from systematic based approach and K/A catalog.

Essential:
None.

Design Assumptions:
- Adaptability to change as plants and equipment evolve over plant life (including plant simulator concept)
- SMR vendors will supply basic content (e.g., 3-D CAD drawings) for SMR design-related subjects and supplied components necessary to support advanced, technology-based training methods.
- Training will be designed to apply to both permanent and transient (e.g., outage) plant staff.
- Design teams will strive to minimize the burden on these technologies and the overall training effort by considering associated training impacts of design decisions. Helpful design actions are minimizing active components and reducing plant and control systems complexity.

Project Management and Construction Assumptions:
- EPC contractors and SMR vendors will provide plant training source material (e.g. 3-D CAD models of components) necessary to support advanced training capabilities. Ideally the combination of the EPC and SMR vendor will provide all training material necessary for their scope in a technology enabled manner. This is estimated to be >85% of all needed plant staff training material. Owner/operator will add company and site-specific elements. This is estimated to be <15% of all needed plant staff training material.

Plant Operational Assumptions:

- Training technology and materials will be adopted/updated to reflect plant procedure and hardware modifications over plant life.
- The plant will use the capability provided by this TDD to maximize 1) cross-training of staff between training and other staff functions, and 2) routine use of the practice of rotating personnel between training and other staff areas.
- The plant will maximize the benefits of this advanced technology by automating many of the administrative burdens now placed on training staffs such as; integration with plant master schedules, electronic training procedures, automated updating and access to individual training records.

Key captured information:

- EPRI ANT Project 2016-M: Augmented Reality – Scoping Study for New Plant Project Applications
- EPRI Automated training content for plant components – available through EPRI Nuclear Sector program 41.05.01 Nuclear Maintenance Applications Center (NMAC)
- EPRI Engineering Technical Training Modules – 50 modules covering engineering basics of nuclear power available through EPRI Nuclear Sector program 41.05.05 Plant Engineering Program (PE)
- EPRI Standardized Task Evaluation (STE) Program within the Plant Technology Department

Regulatory:
None.

Functional Areas:

TR-1	Task List Maintenance
TR-5	Mock up development and maintenance
TR-8	Training Records
TR-9	Maintenance Schedule
TR-13	Qualification Card Development and Maintenance
TR-15	Training Materials Development and Maintenance
TR-20	Professional Continuing Training Program (Engineer, Supervisor, Work Planner, etc.)
TR-28	Instructor Development (Training & Qualification)

Potential staffing annual impact:
Operations, Training and other staff areas would see a high (5-10 FTE) decrease in staff due to streamlined, automated methods for training delivery, increased training effectiveness, and an increased ability to cross-train and use training personnel for other staff functions.

Other comments provided for perspective and insight for the next group working with this TDD:
- Design and plant-specific content should be developed on existing, available training, gaming, and virtual reality platforms (leverage these state of the art technologies)

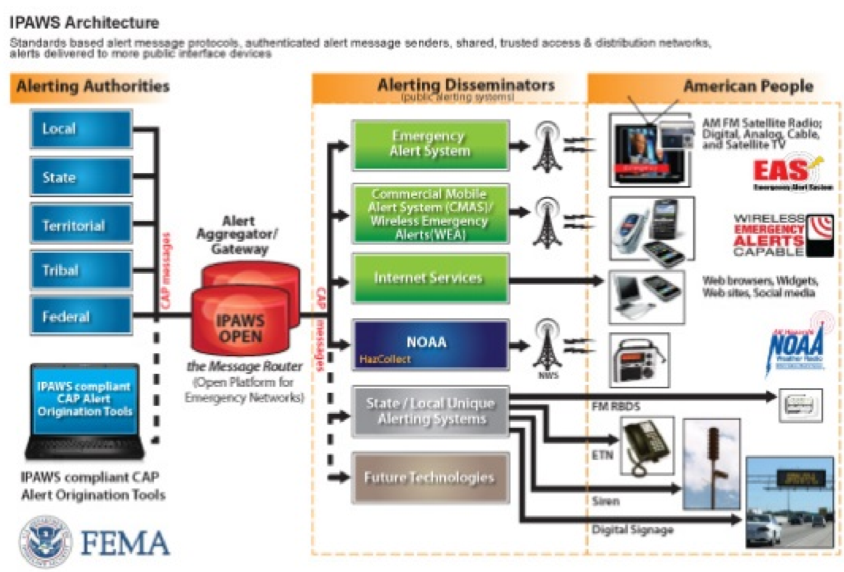
Proposed next steps:
EPRI
- Establish project to evaluate technology options, software platforms and approaches for use by SMR design community in developing training content. Consider how these capabilities build-forward from systematic approach to training and the K/A catalog.

SMR Vendors/EPC
- Consider including user-ready training material in the scope of supply.
- This TDD is considered available for implementation.

TDD EP1 Use of IPAWS Public Notification System for Emergency Communications
Priority Rank: C

Responsible Team:
TAG: Dan Stout/Peter Hastings
SME: Matt Gibson
EPRI Project: Leonard Loflin

Technology and Design Details:
Public notification technology has developed rapidly in the last few decades and the opportunity to leverage public services to transition away from owner-provided alerting systems is now possible. While current regulatory guidance may seem to prevent this, clear demonstration of the effectiveness of the existing and growing government-mandated alerting systems to have a high efficacy for nuclear evacuation alerts would allow their exclusive use for EPZ evacuation response. The FEMA sponsored IPAWS system (see conceptual diagram below) provides multi-modal alerts to a variety of channels that include localization capabilities. Of particular interest is the Wireless Alert System (formerly CMAS) that provides localized alerting via mobile devices.



Development Needs:
<u>Enhanced:</u>

- Assess the use of IPAWS and WEA (Wireless Emergency Alert) to replace existing siren and custom notification technologies.
  - Define site unique specifics necessary to justify use of IPAWS.
  - Determine the effectiveness and reliability of IPAWS and WEA relative to the current siren and text message systems.
  - Conduct a pilot integration and demonstration to validate reliability and usability assumptions.

Essential:
- None.

Design Assumptions:
- There should be little or no equipment on owner premises.
- Interface would be through a local alerting authority (county/state).
- Testing and maintenance is the responsibility of alert disseminators not the plant owner.

Project Management and Construction Assumptions:
None.

Plant Operational Assumptions:
- Invisible to operational staff

Key captured information:
FEMA website (https://www.fema.gov/integrated-public-alert-warning-system) for details.

Regulatory:
- Assure that on-going SMR EPZ regulatory interactions (NEI follow of TVA and NuScale efforts) provide performance requirements that allow use of this technology.
- Determine regulatory actions needed, if any. Which government agency has the lead (NRC, FEMA, others?). Are existing regulations sufficiently flexible to allow implementation of the technology?

Functional Areas:
EP-13 Evacuation- EPZ

Potential staffing annual impact:
FTE reduction could be notable based on the utilities' current involvement with offsite alerting. Assigning the requirement (and maintenance) to the Alerting Authorities entirely would reduce planning and interface requirements at a minimum. Elimination of siren maintenance could reduce staff by 1-2 FTE for a large plant. Other administrative reductions due to elimination of sirens may be 1 FTE.

Other comments provided for perspective and insight for the next group working with this TDD:
- The time has come to take a close look at the growing public capability for emergency alerting. The legacy regulatory and utility approaches should be updated to a 21st century approach.
- Modern alerting systems can provide detailed and refined information to the public that avoids the ambiguity and potential confusion of the current alerting systems.

Proposed next steps:

EPRI:

- Conduct implementation study and gap analysis for IPWAS/WEA alerting (see Enhanced Development needs).
- Conduct pilot project with interested utility if needed to demonstrate adequate functionality to meet regulatory requirements.

TDD EP2 Remote and Alternate Facility Implementation
Priority Rank: B

Responsible Team:
TAG: Spence Semmes, Gary Ruf
SME: Matt Gibson
EPRI Project: Leonard Loflin

Technology and Design Details:
Use modern communications technology to create "virtual" ERO (Emergency Response Operation) facilities that ease the burden of facility manning, design, construction, and maintenance. Using current and planned commercial LTE (Long Term Evolution) services or internet service-provider networks, ERO members would join the virtual alternate ERO facility from their homes, remote work location, or ad-hoc sheltering location. This can be achieved by the use of private, secure virtual networks (MPLS, or carrier custom implementations). A virtual alternate ERO would reduce the security manning and technology support requirements of the alternate ERO facility. It would provide enhanced employee safety during events that prevent the use of the normal ERO facility such as hostile action or severe natural event.

Development Needs:
<u>Enhanced</u>:

- Develop an optimized configuration with best attainable Service Level Agreement (SLA) for a virtual ERO facility.
- Develop/identify enhanced software application to integrate into this ERO function.

<u>Essential:</u>

- Conduct a pilot integration and demonstration to validate reliability and usability assumptions.
- Develop Client device profiles and target functionality.
- Assess achievable system reliability and availability.
- Ensure Cyber security issues are addressed, as they apply to emergency situations.

Design Assumptions:

- The reliability of the commercial LTE network or wired ISP is at least as good as any custom alternate ERO design and likely also as good as an individual's ability to physically get to the plant site, e.g., in a significant national disaster.
- Human factors and usability are fully evaluated and implemented.
- The use of common HMI and user constructs will ease usability issues.
- Embrace the results of the above Development tasks in the detailed design.
- Configuration and capabilities should minimize plant staff training requirements.

Project Management and Construction Assumptions:
None.

Plant Operational Assumptions:
- Data and application sources are available to feed the alternate virtual ERO function.
- Stranded operators will be able to interact with the virtual Alternate ERO facility.

Key captured information:
None.

Regulatory:
Data integrity and need for some join interaction must be addressed (see requirements in NUREG 0800, NUREG-0696, and NUREG-0654).

Functional Areas:
EP-16 Remote and Alternate Facility Implementation

Potential staffing annual impact:
FTE reduction would be 3 to 5 in the above functional area, based on reduced support and technology support functions and elimination of facility maintenance and testing. Additional FTE reduction is possible, stemming from innovative reduction in ERO manning requirements based on a virtual ERO. Security coverage necessary for on-site ERO facilities could also be reduced. Total FTE impact could exceed 5 FTE.

Other comments provided for perspective and insight for the next group working with this TDD:
- The use of virtual ERO facilities can be explored for normal ERO use as well to reduce the ERO response time, ensure ERO member safety, enhance facility availability, and minimize facility upkeep.
- Virtual conferencing, virtual reality and other tools are available to create a remote presence using commodity hardware and software.
- Essential elements will be the development, refinement, and demonstration of effective use scenarios and mitigation of any key issues.
- Ninety-nine percent of ERO man-hours are spent in training; therefore optimizing the system for ad-hoc and individualized training and competency development will be key.
- Implementation of an alternate ERO facility as described in this TDD could possibly enable elimination of physical ERO facilities.

Proposed next steps:

EPRI:

- Conduct integration study and gap analysis for a virtual Alternate ERO facility
- Develop an integrated pilot system for test and demonstration.
- Conduct pilot project with interested owner.

TDD SC1 Supply Chain and Procurement Engineering Tools
Priority Rank: A

NOTE: TDD SC1 functionality is closely related to that of TDD E1, Engineering Tool Set. Consideration should be given by users to joint deployment of these two TDDs to take advantage of development efficiencies and to optimize staff reductions achieved.

Responsible Team:
TAG – Spence Semmes
SME – Marc Tannenbaum
EPRI Project – Kyle Turner

Technology and Design Details:
Establish an “above average” Enterprise Asset Management system that is fully populated, as a minimum, with the supply chain related data in Attachment 1 to TDD-SC1 prior to initial plant operations.

Ideally, stocking levels and reorder parameters will be established in advance. Demand for replacement items is automated. When a task to be worked is scheduled, the system will check to see if the necessary quantity will be available on the start date. If not, a reorder notice will be generated. Pre-negotiated agreements and pricing would further reduce the need for manual involvement in the purchasing process. The vast majority of reorders will be awarded to the NSSS or their designated source of supply. This will facilitate batch processing that will decrease the number of purchase order, invoice, and accounts payable transactions necessary to support procurement.

Obsolescence Considerations:
The NSSS will include terms and conditions in contracts with sub-tier suppliers to notify the NSSS/licensees when the future sales volume information for each item that is purchased to be a part of the plant is decreasing to a point where sales may not support continuation of the item (the item is nearing obsolescence).

The NSSS will include terms and conditions in the contracts with sub-tier suppliers to maintain a complete set of design and manufacturing information for each item that is purchased to be a part of the plant in “escrow” so that the information may be made available to the NSSS and licensees in the event the sub-tier supplier goes out of business or ceases support of the product.

Development Needs:
<u>Enhanced:</u>

- Capture for industry use the specific characteristics of “above average” EAM systems design and implementation that assure they will be a long term benefit and avoid them being a detriment to plant operations.
- Pre-negotiated agreements on pricing and to share technical data will need to be developed. It may be possible for the NSSS to host the equipment list and bills of material to reduce manual involvement in the procurement process. A platform to enable B2B communication would need to be established.

Essential
None.

Design Assumptions:

- Assembly of the necessary EAM data must be part of the original procurement activities for all plant equipment. See EPRI 1021416 *Equipment Reliability for New Nuclear Plant Projects – Industry Recommendations for Procuremen*t for perspective.
- Existence of up-to-date 3D plant model accurate to necessary design engineering tolerances.
- Software package used by design engineer and constructor should be forward-compatible to the package used by the owner/operator.
- The design capability of the EAM and its contents will encompass aspects of design and configuration control essential for post operation plant changes which may not be required for original design (i.e. interaction with plant procedures, support of plant procurement activities).
- Fully populated data shall be provided prior to plant start-up. This will facilitate commencement of normal procurement and maintenance activities without the need for data recovery projects such as bill of material projects, walk-downs, vendor manual projects, safety classification projects, and so forth.

Project Management and Construction Assumptions:

- The EAM for parts availability and supply capability will be used early and often during construction maintenance and startup operations. This will maintain essential history and data for plant operations and project ITAAC (Inspections Tests Analysis and Acceptance Criteria) needs.
- EPC contractor will provide a specification for required equipment information to be provided as a contract deliverable in a form compatible with the requirements of the EAM package selected for the project by the owner/operator.
- The contractor turnover package for each system will include the entire data package (i.e., all necessary design data to maintain, modify and operate the plant).

Plant Operational Assumptions:

- Operator maintains the underlying plant model data current to actual plant configuration.
- Plant procurement processes and systems are capable of automated B2B communication with applicable databases.
- The plant Owner maintains the right and ability to make changes to equipment data as needed and justified for their plant within and outside of the boundary of the Standardized Plant.

Key captured information:

- TDD SC1 functionality is closely related to that of TDD E1, Engineering Tool Set. Consideration should be given by users to joint deployment of these two TDDs to take advantage of development efficiencies and to optimize staff reductions achieved.
- Assembly of data to populate the EAM must begin with initial procurement of engineered equipment.

Regulatory:
The project should determine the role of the EAM in documenting achievement of ITAAC requirements and maintaining ITAAC completion status.

Functional Areas:
Implementation of this TDD would provide potential staff reductions and efficiencies distributed across the staff functional areas listed below, by improving the ability to access, analyze, use and communicate plant engineering information and by automating design processes, where possible.

SC 01-13
PE 001-016

Potential staffing annual impact:
Significant reduction in supply chain staffing (> 5 FTE).

Other comments provided for perspective and insight for the next group working with this TDD:

- Early implementation of this concept dramatically reduces late-in-project "re-creation" of essential information.
- Recent owner/operator experience has emphasized the importance of selecting and fully populating an "above average" Enterprise Asset Management system. "The selection of an above average Enterprise Asset Management system is critical to the long term efficiency of the entire plant organization".

Proposed next steps:

- SMR Vendors
  - Detail the actions necessary to establish the EAM with needed data at the optimum time on proposed projects.
  - Determine the role that the EAM will play in the ITAAC completion and status maintenance process.
- EPRI
  - Capture the characteristics of successful EAM design and implementation.
  - Determine the tasks and effort necessary to upgrade existing EAM systems to communicate with SMR Vendor systems.

Attachment 1 to TDD-SC1

- Equipment List
  - Unique Equipment ID
  - System Designator
  - Safety Classification
  - Description
  - Original Equipment Manufacturer and Part Number
  - NSSS Part Number (as applicable)
  - Total quantity of that device installed in the plant
  - Vendor technical and maintenance manual references
- Bills of Material (should be consistent with interactive 3-D drawings of each piece of equipment that include the entire piece of equipment with capability to open exploded views of assemblies and parts) For each item on the bill of material
  - Original Equipment Manufacturer and Part Number
  - Quantity
  - Original Equipment Manufacturer's recommended spare parts list
  - Functional Safety classification
  - Applicable specifications
  - Criticality classification
  - Flag for stocked item with stock keeping unit (SKU)
  - Flag for critical spare
  - Flag for maintenance spare
  - Flag for obsolete item (available, approaching, obsolete, replacement solution available)
- Preventive Maintenance Tasks
  - Maintenance intervals
  - Items (SKUs) required for each maintenance task
  - Quantity of each SKU required for each maintenance task
  - Consumables required for each maintenance task (lubricants, rags, packing, gaskets, etc.)
  - Quantity of consumables required for each maintenance task

TDD WH1 Automated Parts Supply
Priority Rank: A

Responsible Team:
TAG: Todd Oswald
SME: Marc Tannenbaum
EPRI Project: Kyle Turner

Technology and Design Details:
Technology and design aspects of selected warehouse locations should be fully compatible with maintenance connectivity TDD M3. This should include maximum automation of parts requests, warehouse acknowledgement, part location and identification, access to and movement of the part, verification and release from warehouse, part return when needed. This is enabled by TDD SC1.

Development Needs:
Enhanced:
None.

Essential:
None.

Design Assumptions:
- Databases must support configuration management interoperability.
- Plant communications, layout and warehouse space allocations are determined with this capability in mind.

Project Management and Construction Assumptions:
None.

Plant Operational Assumptions:
- Implement these concepts during plant warehouse support to construction and startup maintenance tasks.

Key captured information:
- Rolls Royce has this functionality in a supply chain offering.

Regulatory:
None.

Functional Areas:
The following functional areas will see staffing reductions as a result of implementing this TDD.

WH-3	Receiving
WH-4	Put-Away
WH-5	Store
WH-6	Facilitate In-Storage Maintenance
WH-7	Facilitate Shelf Life Program
WH-8	Cycle Count
WH-9	Pick
WH-10	Stage
WH-11	Issue

Potential staffing impact:
Warehousing would see a staff reduction impact of 4-5 FTE across the functional areas listed above. Associated maintenance staffing savings would accrue. Assume total impact will exceed 5 FTE.

Other comments provided for perspective and insight for the next group working with this TDD:
- Development and implementation of this TDD should be integrated with efforts to implement TDD M3 Maintenance Connectivity.

Proposed next steps:
- SMR Vendors
  - This TDD is considered available for SMR project teams to incorporate into their designs.

TDD S1 Target Set Reduction
Priority Rank: A

Responsible Team:
TAG, SME – Farshid Shahrokhi
EPRI Project – Leonard Loflin

Technology and Design Details:
Use design options that reduce the number of potential targets in the plant layout. The reduction of target sets can be accomplished by implementing the following methods during the initial plant design and physical layout:

- Use of passive methods for ultimate core cooling
- Design features that cannot be activated or deactivated that results in inoperable core cooling conditions
- Utilize core cooling technologies or defensive barrier technologies that rely on inherent material properties and do not require external power to activate.
- Location of targets vs necessary reaction time needs should be considered (i.e. reduce number of ready rooms)

Development Needs:
Enhanced:
Develop technology options that use inherent material properties or passive systems that reduce target sets.
Essential:
Need to define a list of typically vulnerable targets associated with the various SMR plant design. Once these target sets are defined, identify actions to eliminate them from the design if possible, and if not, minimize the significance of the damage if compromised.

Design Assumptions:

- Plant civil and structural design process to include concurrent/in process security review cycles
- Plant design minimize access points to vital plant areas within the bounds of personnel safety
- Plant vital areas are located partially or completely below grade

Project Management and Construction Assumptions:
None – The target set reduction activities are performed during plant design. Once the plant design is ready for constructional target sets are known and cannot be changed after construction

Plant Operational Assumptions:
None – The target set reduction activities are performed during plant design. Once the plant operational target sets are known and cannot be changed.

Key captured information:
Key design information necessary for target set reduction is considered "safeguards information" and is specific to individual plant designs.

Regulatory:
NEI plant SMR security white paper has been prepared for NRC review. This white paper proposes that due to lower source term for SMRs the approach to SMR plant security be changed from "detect, assess, interdict and neutralize" to "detect, assess and communicate," using a consequence-based framework for security plan evaluation. Acceptance and implementation of this approach by the NRC in concert with reduced SMR target sets is critical to success of SMR security staff optimization.

Functional Areas:
- Plant safety design features
- Civil structural design
- Security plan

Potential staffing annual impact:
The SMR security staffing levels are not public information and will be "safeguards'" information when they are known. However, given that security staffing is a major nuclear plant staffing component and reduced target sets will reduce security staff requirements, potentially significant staff reductions are possible.

Other comments provided for perspective and insight for the next group working with this TDD:
- This TDD was developed in conjunction with the NEI security working group focusing on SMRs. Contact with that group and/or members of the group could provide more insight into best application of these concepts.

Proposed next steps:
<u>EPRI</u>
- Establish a close contact with NEI SMR Security Working Group to remain aware of productive R&D efforts that should be pursued

<u>SMR Vendors/EPC</u>
- Implement target set reductions in their designs, based on NRC regulatory policy for security at SMRs.

TDD S2 Security Barrier Location and Effectiveness
Priority Rank: B

Responsible Team:
TAG, SME - Farshid Shahrokhi
EPRI Project - Leonard Loflin

Technology and Design Details:
Use barrier designs that provide enhanced security and superior effectiveness. Security barrier locations can be designed in to the plant layout as follows:

- Use of passive intrusion detection
- Use of fortified passive barrier technology
- Use of personnel identification technology to limit access only to authorized personnel
- Use of multiple and diverse physical barriers to delay unauthorized access attempts

Development Needs:
<u>Enhanced:</u>

- Engineered fortification methodology. This includes both thought process when in the design phase and design concepts that reduces or eliminates threats and or targets.
- Improved materials with verification/qualification testing.

<u>Essential:</u>
None

Design Assumptions:

- Enhanced security barriers shall not impair safe operation of the plant or authorized access to plant vital areas.
- Allow early intrusion detection
- Support "detect – assess – communicate" security philosophy
- Increase use of automation to reduce vulnerability

Project Management and Construction Assumptions:
None – The barrier designs are provided during plant design.

Plant Operational Assumptions:
Enhanced security barriers must operate during all modes of plant operations. By-pass or inoperable security barriers must be alarmed.

Key captured information:
None

Regulatory:
NEI plant SMR security white paper has been prepared for NRC review. This white paper proposes that due to lower source term for SMRs the approach to SMR plant security be changed from "detect, assess, interdict and neutralize" to "detect, assess and communicate," using a consequence-based framework for security plan evaluation. Acceptance and implementation of this approach by the NRC in concert with reduced SMR target sets is critical to success of SMR security staff optimization.

Functional Areas:
- Civil structural design
- Security plan

Potential staffing annual impact:
The SMR security staffing levels are not public information and will be "safeguards'" information when they are known. However, given that security staffing is a major nuclear plant staffing component and reduced target sets will reduce security staff requirements, potentially significant staff reductions are possible.

Other comments provided for perspective and insight for the next group working with this TDD:
- This TDD was developed in conjunction with the NEI security working group focusing on SMRs. Contact with that group and/or members of the group could provide more insight into best application of these concepts.

Proposed next steps:
<u>EPRI</u>
- Pursue Enhanced Development Needs stated above.

<u>SMR Vendors/EPC</u>
- Implement improved barrier location and effectiveness in their designs, based on NRC regulatory policy for security at SMRs.

TDD S3 Design Vulnerability Reduction
Priority Rank: A

Responsible Team:
TAG, SME – Farshid Shahrokhi
EPRI Project – Leonard Loflin

Technology and Design Details:
Reduce vulnerability to radiological sabotage provided by engineered protection systems while reducing or eliminating reliance on human actions. The functionality must provide high assurance that activities involving special nuclear and high level waste material are not inimical to common defense and security, and do not constitute an unreasonable risk to the public health and safety.

The reduced vulnerability can be accomplished by implementing the following methods during the plant design and physical layout:

- Use of passive methods for ultimate cooling
- Reduced access points to waste nuclear material
- Remote or automated handling of waste nuclear material
- Automated handling of waste nuclear material
- Consolidate and physically monitor and protect remaining vulnerability points

Development Needs:
<u>Enhanced:</u>

- Reduce target sets (TDD S1)
- Enhance physical barrier efficiency (TDD S2)

Design Assumptions:
Plant designers have a general knowledge of plant security issues such that during initial design limited vulnerability points associated with these type materials are created.

Project Management and Construction Assumptions:
Field modification and construction changes are reviewed for by security aware design engineers.

Plant Operational Assumptions:
None.

Key captured information:
None

Regulatory:
NEI plant SMR security white paper has been prepared for NRC review. This white paper proposes that due to lower source term for SMRs the approach to SMR plant security be changed from "detect, assess, interdict and neutralize" to "detect, assess and communicate," using a consequence-based framework for security plan evaluation. Acceptance and implementation of this approach by the NRC in concert with reduced SMR target sets is critical to success of SMR security staff optimization.

Functional Areas:

Potential staffing annual impact:
The SMR security staffing levels are not public information and will be "safeguards'" information when they are known. However, given that security staffing is a major nuclear plant staffing component and reduced target sets will reduce security staff requirements, potentially significant staff reductions are possible.

Other comments provided for perspective and insight for the next group working with this TDD:

- This TDD was developed in conjunction with the NEI security working group focusing on SMRs. Contact with that group and/or members of the group could provide more insight into best application of these concepts.

Proposed next steps:
EPRI

- Pursue stated Development needs

SMR Vendors/EPC

- Implement special nuclear material and waste security in their designs, based on NRC regulatory policy for security at SMRs.

D
SMR TECHNOLOGY AND DESIGN DETAIL STAFFING IMPACT MODEL

D.1 Model Concept

The focus of this report and the associated project is the use of technologies and design details to optimize staffing levels for SMR. Unfortunately, many technologies and design changes have been incorporated into nuclear plant designs (pre-operation and post-operation) with great expectations for staffing improvement but with little or no positive impact on staffing.

The model that follows describes the "due diligence" that is necessary to move from technical idea to staffing improvement. Both SMR design teams and SMR operating staffs can use this simple logic to increase the probability that good intentions turn into good staffing results.

Two aspects of this model are improvements over other typical approaches. The first is the emphasis on identification of specific detailed plant functions that are impacted. Second, it requires ownership of the projected impacts by the people who must use the technology or design detail to achieve the actual staffing improvements. This project allows these improvements by assembling in Appendix A of this report detailed function listings for almost all plant groups.

Cost benefit is the root of most staffing actions. This model establishes the allowable cost (or budget) in Step 3. Step 7 compares the expected benefit for the budget allowed. Step 9 validates the benefit before proceeding.

The model is provided in Figure D-1; descriptions and perspective on individual model steps are provided in Section D.2.

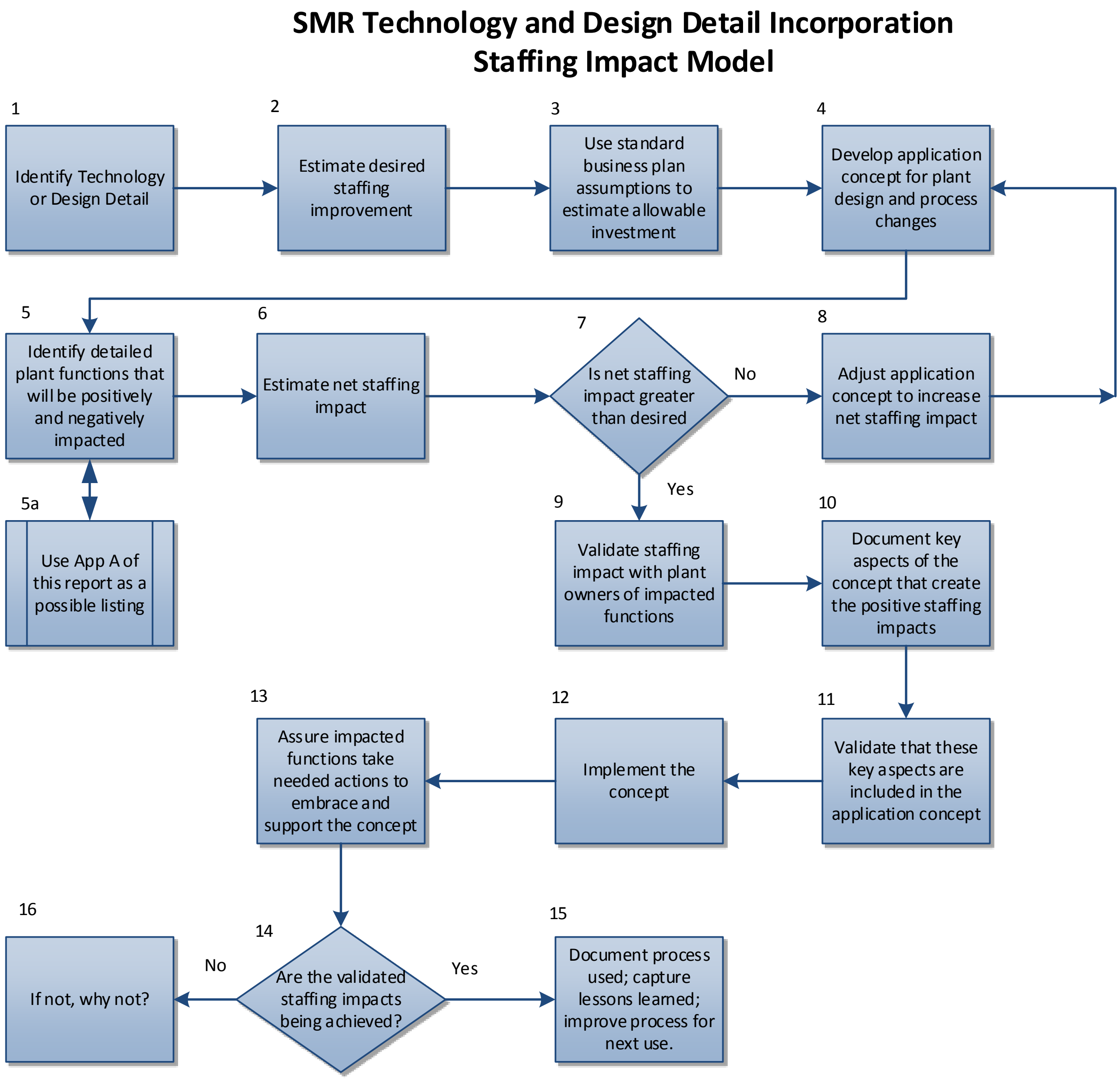


Figure D-1
SMR Technology and Design Detail Staffing Impact Model

D.2 Model Steps

1. Technologies and design details (TDDs) may simply appear with obvious staffing improvement potential. At other times, staffing improvement may be a necessity requiring TDDs to be sought out and embraced. Regardless of what initiated the effort, staffing improvements do not happen by wishing. They happen by due diligence.
2. Design, be it plant technical detail or plant process, is iterative. Start with the best, balanced estimate of the realistic staffing improvement that appears achievable.
3. Any increment of staffing has a financial value. The plant business plan or project financial assumptions will contain a process that will allow you to convert an estimated number of Full

Time Equivalents (FTE) into a dollar value. The business plan will further provide the return on investment period that will be required for the plant to authorize the proposed changes. With this information you can estimate the potential funds available to accomplish the staffing impact estimated.

4. With a funding estimate available and a technology identified, the real work of creating the design concept for incorporation of the technology into the plant hardware and the plant processes can be accomplished.
5. (and 5a) To be successful, you must identify where in the plant staff the changes (positive and negative) will occur. Just saying “Radiation Protection” is not enough. You must identify the specific functions within “Radiation Protection” and other plant functions that will see the impact. Most plants do not have a readily available listing of the tasks and sub-functions within each plant organization. As part of this project, detailed function listings have been assembled for almost all plant organizations. These are available in Appendix A of this report (EPRI product 3002007071).
6. (and 7) Knowing your net staffing impact allows a sanity check against your desired staffing impact that was your basis for financial investment. If your staffing impact is low, rework your concept (8). If your staffing impact is equal to or above your desired FTE amount, proceed to (9).
9. (and 10) Reality sets in when seeking agreement with the plant organizations that “own” the functions being impacted. Each owner will have various concerns about the impact of the changes being considered. They will ask about specifics that are critical to them. They will qualify their agreement to any staffing impact with conditions that must exist. It is important that you capture and document each of these critical concerns and conditions.
11. Once these “owner” concerns and conditions are known, validate that they are achieved/addressed in the design and/or implementation of the concept. If they cannot be achieved, revisit with the owner of the function to understand the impact of the limitation encountered.
12. Implement the concept. This is easy to say but hard to do. Have a good implementation plan and follow its execution in detail. Sometimes many months or years pass between creation of the detailed plan and its implementation. Be sure the documentation and plan allow a competent person in the future to be successful and achieve the positive staffing impact intended.
13. A very important portion of the implementation plan is that each of the owners of the impacted plant functions take the actions necessary for the staffing impacts to be achieved. This means procedure changes, training, process revisions, and any other needed actions on their part.
14. At the right point in time, do a headcount to validate that intended staffing impacts have been achieved.
15. If the process was successful, document how and why it was successful (capture lessons learned). Capture these for future use.
16. If staffing has not been reduced to the extent intended, determine why and correct the condition if at all possible. Again, capture the lessons learned.

E

TDDS BY EPRI TECHNOLOGY READINESS LEVEL

The individual Technology and Design Detail (TDD) write-ups contain specific Development Needs (see Table 4-2 for an overview). Consideration of the complexity (or lack thereof) of these Development Needs is an indicator of the "readiness" of the technology and/or design concept being proposed. However, when placed in competition with other industry needs, it helps to have a common frame for considering the level of maturity and/or extent of needed development work.

The U.S. Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and EPRI have all developed scales for communicating technology maturity. This report uses the EPRI scale, which is shown in Table E-1.

Table E-1
Technology Readiness Levels

TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9
Exploratory Research	Lab Test	Subsystem Develop-ment	Subsystem Validation	Subsystem Feasibility	Early Demon-stration	Prototyping Demon-stration	Early Commercial Deployment	Commer-cialization

TRL 1 – Exploratory research transitioning basic science into laboratory application
TRL 2 – Bench-scale laboratory testing to validate basic concepts
TRL 3 – Subsystem or component development refined
TRL 4 – Subsystem or component validation in simulated real-world environment
TRL 5 – Early system feasibility demonstrated in laboratory or limited field application
TRL 6 – Early field demonstration and system refinements completed
TRL 7 – Complete system prototyping demonstration in an operational environment
TRL 8 – Early commercial deployment
TRL 9 – Wide-scale commercial deployment

Table E-2 assigns a Technology Readiness Level to each of the 25 TDDs identified in this report.

Table E-2
TDD Technical Readiness Levels

TDD Number	TDD Title	TRL*
C1	Automated Sampling and Analysis – Chemical	TRL 6
C2	Automated Sampling and Analysis – Radiological	TRL 6
C3	Chemical and Radiological Analysis Software Suite	TRL 5
RP3	Automated Personnel Monitoring and Dosimetry	TRL 6
RP4	Automated ALARA Job Reviews and RWP Generation	TRL 6
RP5	Automated Radiation Monitoring and Analysis	TRL 6
RP9	Automated Public Dose Assessment for EP	TRL 5
M1	Standardized Components	TRL 9
M2	Cross-Training of Maintenance Staff	TRL 9
M3	Connectivity	TRL 7
M4	Automated Electronic Mobile Work Management	TRL 8
M5	Design for Maintenance Effectiveness and Efficiency	TRL 9
E1	Engineering Tool Set	TRL 7
E2	Automated Plant Health Management System Assuring Plant and Equipment Reliability	TRL 6
E3	Engineering Program Automation	TRL 6
O1	Intelligent Configuration Management Optimization	TRL 5
O2	Automation of monitoring, analysis, operational functions including Electronic Procedures	TRL 6
T1	Use of Advanced, Technology-Based Training Methods	TRL 9
EP1	Use of IPAWS Public Notification System for Emergency Communications	TRL 9
EP2	Remote and Alternate Facility Implementation	TRL 5
SC1	Supply Chain and Procurement Engineering Tools	TRL 8
WH1	Automated Parts Supply	TRL 7
S1	Target Set Reduction	TRL 8
S2	Security Barrier Location and Effectiveness	TRL 6
S3	Design Vulnerability Reduction	TRL 8

*These TRLs capture the "general" condition of the technology and/or design concept. A TDD might have specific needs that require a lower TRL. Likewise, each TDD will have aspects that are currently fully commercial.

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