Nuclear Asset Management (NAM) Toolkit – Definition and Industry Survey

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ABSTRACT

The NAM Toolkit represents identification and evaluation of existing tools (both EPRI and other commercially available off-the-shelf (COTS) tools) that support asset management analysis and decision-making activities. The Toolkit concept is intended to provide utilities with a selection of tools from which those that best meet the business models and objectives of the organization can be selected. As a first step in the specification of this Toolkit, preliminary research into the identification and classification of tools that are currently available was performed. To accomplish this objective, a survey of industry NAM participants was conducted to ascertain those tools which currently are employed to conduct the activities specified in the "Nuclear Asset Management Process Description and Guideline" NEI AP-940. This report describes the results of this survey and provides recommendations for further research to fill identified gaps in currently available technology.

Keywords

Nuclear Asset Management
Risk Informed Asset Management
NAM Toolkit
AP-940

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Utility Survey Participants

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PURPOSE OF NAM TOOLKIT

Nuclear Asset Management (NAM) provides a fundamental cornerstone on which commercial nuclear power facilities are managed to achieve competitive economic performance within the constraints imposed upon them. These constraints include regulatory requirements necessary to maintain the facility operating license and economic factors imposed by a large and diverse group of stakeholders (federal, state and local governments, customers, corporate shareholders, employees, etc.).

Due to the numerous and diverse attributes which influence NAM, the industry has developed a structured methodology that catalogs the activities necessary to effectively conduct NAM evaluations and make appropriate business decisions. This document was developed using industry experts and was published by the Nuclear Energy Institute (NEI) as AP-940; "Nuclear Asset Management Process Description and Guideline" [1]. This document identifies those functions that are required to evaluate and value nuclear plant assets to support business decision-making. It also serves as a standard from which organizations may conduct self-assessments of their business practices. For the purposes of the NAM Toolkit, the classification provided in AP-940 is viewed as a useful structure against which implementation tools can be classified and evaluated. A listing of the functions identified in AP-940 is provided in Table 1-1 below.

In AP-940, each function is displayed in a flowchart format. Level 1 provides an overview of the top-level processes (indicated as Level 1 Primary Functions in Table 1-1). This level demonstrates the interactions of the top-level processes. Level 2 flowcharts provide intermediate level processes that are required to support the associated Level 1 process. These are indicated as Level 2 Sub-Functions in Table 1-1. Finally, AP-940 furnishes the Level 2 processes with supporting text that provides details associated with the associated Level 2 Sub-Process.

In the conduct of business, operators of nuclear power plants perform each of the NAM functions described in AP-940. As is evident from the listing of these functions in Table 1-1, the performance of any one function requires several inputs and outputs with specialized skill sets to conduct the analysis and draw conclusions. Thus, the activities typically require the interaction of many departments in the organization. This situation requires effective communication and interactions between personnel responsible for accomplishing the respective activities. Additionally, the AP-940 process document describes these processes at an overview level. Details associated with their accomplishment are not provided. Thus, although this document serves as a useful classification scheme, it does not provide detailed guidance on how the functions should be accomplished.

Table 1-1
NEI AP-940 NAM Functions (1)

Level 1 Primary Function	Level 2 Sub-Functions
3.1 – Strategic Planning	3.1.1 – Collect and Evaluate Stakeholder Input 3.1.2 – Analyze Strengths, Weaknesses, Opportunities and Threats (SWOT) 3.1.3 – Identify Strategies and Alternatives 3.1.4 – Establish Strategic and Tactical Goals
3.2 – Generation Planning	3.2.1 – System Demand Forecast 3.2.2 – System Resource Forecast 3.2.3 – Gap Analysis 3.2.4 – Generation Plan Development
3.3 – Project Evaluation and Ranking	3.3.1 – Project Submission, Categorization and Screening 3.3.2 – Project Evaluation 3.3.3 – Project Review 3.3.4 – Integrated Prioritization and Selection 3.3.5 – Approvals, Communicating and Monitoring
3.4 – Long Range Planning	3.4.1 – Competitive Analysis 3.4.2 – Project Selection and Capital Planning 3.4.3 – O&M Cost Planning 3.4.4 – Workforce Planning 3.4.5 – Fuel Planning 3.4.6 – Long range Plan Development
3.5 – Budgeting	3.5.1 – Competitive Analysis 3.5.2 – Labor Estimates 3.5.3 – Routine O&M Budget 3.5.4 – Outage Budgets 3.5.5 – Project Budgets 3.5.6 – Fuel Budgets 3.5.7 – Challenge Process 3.5.8 – Final Approval, Reporting and Communication
3.6 – Plant / Fleet Valuation	3.6.1 – Forecasting 3.6.2 – Scenario Development 3.6.3 – Scenario and Risk Analysis and Asset Valuation

Relationship to Risk-Informed Asset Management Business Requirements

Because the NAM Process model as described in AP-940 is provided at an overview level, previous EPRI research has focused on development of processes and tools that support implementation of various key elements. The cornerstone of this research is described in "Risk-Informed Asset Management (RIAM): Method, Process and Business Requirements" [2]. RIAM provides a systematic approach that employs risk management techniques to support long term planning and investment decisions across various levels (e.g. system, plant and fleet). As described in [2], RIAM provides decision makers with a structured approach to analyze various investment alternatives for individual projects as well as project portfolios.

In RIAM, the potential impact on plant reliability, safety, and long term profitability are evaluated in an integrated manner. This is contrasted with the traditional approach of managing these key indicators separately. The RIAM approach provides a means for simultaneously assessing the impact of investment and operational decisions on important plant performance and safety.

A RIAM evaluation consists of three key elements: a nuclear safety model (e.g. a probabilistic risk assessment (PRA) model), a plant reliability model (e.g. a generation risk assessment (GRA) model), and a plant cost model. In application of RIAM, this cost model is intended to be a full cost model including costs such as operations and maintenance (O&M), capital, decommissioning, taxes, nuclear fuel, etc. to the greatest extent practicable. These elements are integrated to arrive at suitable value measures (such as the changes to the net present value (NPV) or internal rate of return (IRR)) against which alternative decisions may be ranked. A simplified flowchart is provided in Figure 1-1. Details of the RIAM process are provided in [2].

Notice that the RIAM process represents a set of discrete modules that interact with each other. This development was intentional and represents the initial concept of the NAM Toolkit. By employing a modular approach, RIAM provides utilities flexibility in selecting the evaluation approaches, metrics and software tools that best meet their individual objectives. The use of a modular approach also leverages existing capabilities and reduces potential redundancies and overlap between application tools. With respect to NAM evaluation tools (i.e. the NAM Toolkit), the RIAM process was developed with the following objectives in mind [2]:

- Support systematic tracing and linking of the individual evaluation modules so the impact of these components on the overall result can be understood.
- Provide a framework that ensures consistency of methods, calculations and interpretation of results.
- Provide a mechanism to evaluate the capabilities and effectiveness of tools and provide a mechanism for identifying where improvements can be made.
- Support the efficient sharing of information and best practices associated with NAM decision-making.

A specific outcome envisioned from RIAM was the specification of a NAM Toolkit that would provide “methods and tools for improved and consistent asset management across all electric industry facilities” [2].

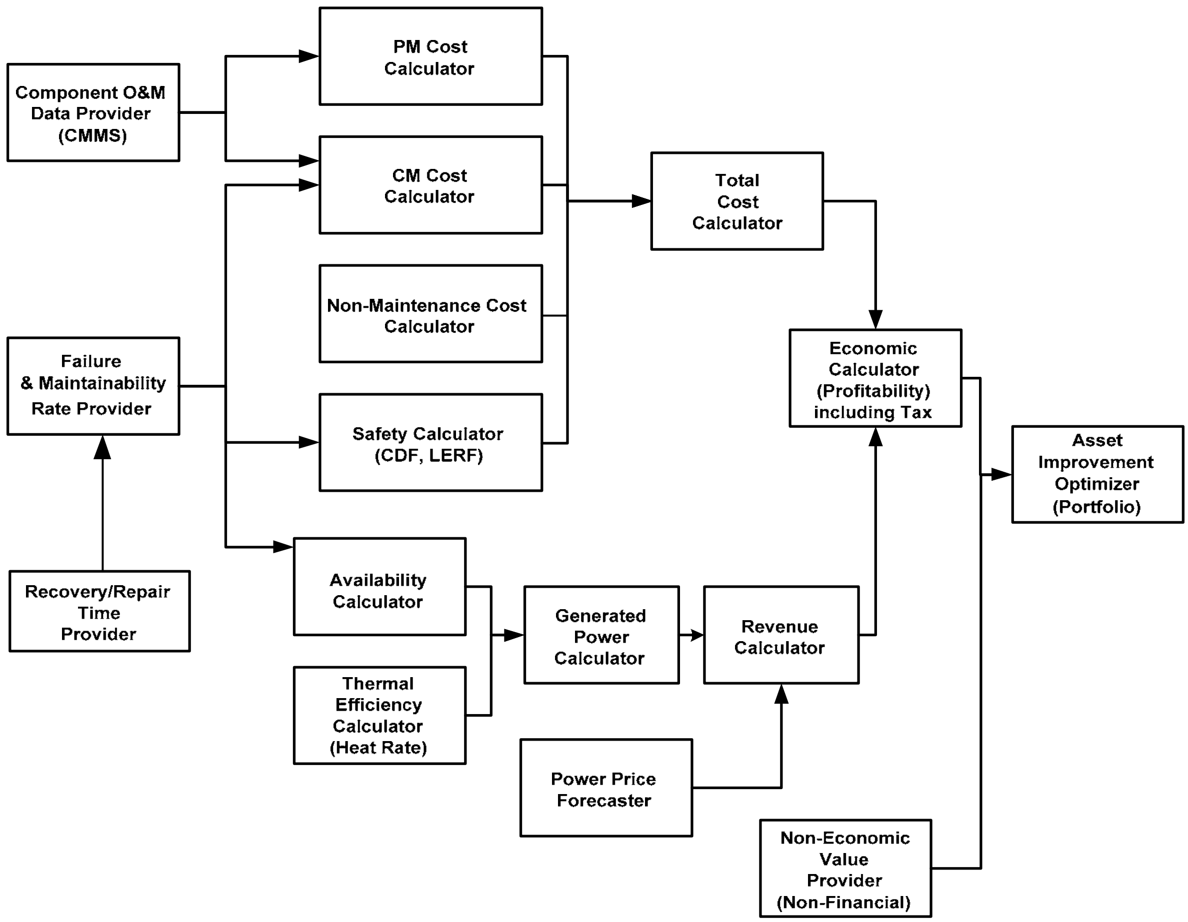

Figure 1-1
RIAM Process Modules

Although RIAM provides a practical framework from which plant engineers and management can evaluate and rank prospective investment alternatives, comparison of RIAM against the AP-940 process requirements demonstrates that RIAM only addresses some of the requirements presented in AP-940. A mapping of RIAM process steps to AP-940 requirements is provided in Table 1-2. In this mapping, only AP-940 processes that have corresponding modules identified in RIAM are shown. In RIAM, the Economic Value Provider (RIAM 3.3) obtains necessary inputs from the following modules.

- RIAM 3.4: Revenue Calculator
- RIAM 3.5: Total Cost Calculator
- RIAM 3.5.1: PM Cost Calculator
- RIAM 3.5.2: CM Cost Calculator
- RIAM 3.5.3: Non-Maintenance Cost Calculator
- RIAM 3.6: Safety Calculator

- RIAM 3.7: Power Price Forecaster
- RIAM 3.8: Generated Power Calculator
- RIAM 3.9: Availability Calculator
- RIAM 3.10: Thermal Efficiency Calculator
- RIAM 3.11: Component O&M Data Provider

Also, in RIAM, the Failure and Maintainability Rate (RIAM 3.12) and the Recovery / Repair Time Data Provider (RIAM 3.13) obtain necessary inputs from RIAM 3.11: Component O&M Data Provider module. For development of the factors included in the Non-Economic Value Provider, an approach such as demonstrated in the pilot enterprise-wide application of Multi-Attribute Decision Theory using EPRI P2 software at the Nebraska Public Power District (NPPD) described in [3] could be used. This approach also could be adopted to integrate the results of the financial and non-economic attributes (AP-940 Steps 3.3.4, 3.4.6 and 3.6.3).

Table 1-2
Mapping of RIAM Modules to AP-940 Processes

AP-940 Level 2 Function	RIAM Modules
3.1.4 – Establish Strategic and Tactical Goals	Input to RIAM 3.2: Non-Economic Value Provider, RIAM 3.3: Economic Value Provider for prioritization and setting of decision criteria.
3.2.2 – System Resource Forecast	RIAM 3.12: Failure and Maintainability Rate Provider, RIAM 3.13: Recovery / Repair Time Data Provider, RIAM 3.11: Component O&M Data Provider (Plant / Fleet Scheduling Tool))
3.3.2 – Project Evaluation	RIAM 3.2: Non-Economic Value Provider, RIAM 3.3: Economic Value Provider
3.3.4 – Integrated Prioritization and Selection	RIAM 3.1: Asset Improvement Analyzer
3.4.1 – Competitive Analysis	RIAM 3.2: Non-Economic Value Provider, RIAM 3.3: Economic Value Provider
3.4.2 – Project Selection and Capital Planning	RIAM 3.1: Asset Improvement Analyzer
3.4.3 – O&M Cost Planning	RIAM 3.5: Total Cost Calculator, RIAM 3.5.1: PM Cost Calculator, RIAM 3.5.2: CM Cost Calculator, RIAM 3.5.3: Non-Maintenance Cost Calculator
3.4.6 – Long range Plan Development	RIAM 3.1: Asset Improvement Analyzer
3.6.1 – Forecasting	RIAM 3.2: Non-Economic Value Provider, RIAM 3.3: Economic Value Provider
3.6.3 – Scenario and Risk Analysis and Asset Valuation	RIAM 3.1: Asset Improvement Analyzer

As can be seen, if RIAM is used to support implementation of AP-940, it must be supplemented by other processes. However, for the purposes of the NAM Toolkit, since the RIAM modules constitute the functions most often performed by analysts and managers at the nuclear plant and fleet levels, they provided the logical starting point for the evaluation of existing tools and the identification of where improvements could be made that would provide near-term payback.

Results of Preliminary Analysis of Existing Tools

As a preliminary step in the specification of the NAM Toolkit, plant personnel responsible for NAM functions initially desired to obtain a comprehensive listing of tools that are available to perform the functions specified in the AP-940 and RIAM processes. The original intent was to identify existing tools that support NAM decision-making and evaluate their capabilities. From this evaluation, a suite of application tools would be identified from which integrated RIAM / NAM decisions could be made. With this information, a gap analysis could be conducted to determine which processes required development of improved tools.

To perform this preliminary step, a brief survey of COTS tools was conducted for three software applications that support key elements of both AP-940 and RIAM. This approach was taken to provide an indication of the feasibility of the approach and also to ascertain what level of effort would be required to achieve the objectives stated above. For this preliminary evaluation, the three processes / software applications selected were:

- Plant Computerized Maintenance Management Systems (CMMS),
- Reliability Engineering Tools,
- Decision Analysis Tools.

These applications were chosen because they are significant to both the AP-940 and RIAM processes. Additionally, they are well known to plant engineering personnel responsible for conducting asset management and equipment reliability evaluations.

In each case, the evaluation process consisted of conducting an internet search (using commercial internet search engines) to identify tools that are designed to possess the desired functionality. From this search, a catalog of tools applicable to each application was developed. For a sampling of identified tools for each application, the vendor websites were accessed and the tools were further evaluated based on the information provided. From these reviews, one tool was selected for a more in-depth preliminary evaluation. The criteria for this selection was that the website provided downloadable literature and/or an on-line tutorial to permit a reasonable preliminary evaluation and that (except for the CMMS software) a demonstration version was available for download to permit further evaluation at a later time. The intent of the review of the selected tool was not to formally evaluate it; but, rather, to determine if a useful evaluation could be conducted using the publicly available information within a reasonable timeframe (e.g. one day or less).

Results obtained for each application are provided below.

CMMS

As large capital intensive facilities, all commercial nuclear power plants have installed integrated CMMS applications software. These systems serve myriad functions, many of which provide data necessary to support NAM analyses and decisions. With respect to AP-940, plant CMMS typically provide information necessary to support the following functions:

- Long Range Planning steps 3.4.3, 3.4.4 and 3.4.5
- Budgeting steps 3.5.2, 3.5.3, 3.5.4, 3.5.5 and 3.5.6

- Long range Planning steps 3.5.2, 3.5.3, 3.5.4, 3.5.5 and 3.5.6
- Plant / Fleet Valuation step 3.6.1

An internet search for tools employed to support asset management identified 60 COTS asset management / enterprise management / CMMS tools identified as applicable for “large” applications (i.e. those applicable to large industrial facilities such as commercial nuclear power stations). However, a significant observation that occurred as a result of these searches is that several CMMS applications known to be used at nuclear utilities were only found by going directly to the supplier’s website (i.e. they were not identified by any of the search engines).

The candidate selected for a more in-depth evaluation consisted of a CCMS that is installed at several nuclear sites. The system also is employed extensively in fossil plant applications. The application tool is an integrated package that operates as Java 2 Enterprise Edition multi-tier enterprise application with modules that support the following functionality:

- work management and tracking
- resource, material and equipment usage tracking
- materials management / inventory tracking and optimization
- procurement management
- contract management

In addition, the CMMS application can link to other third party business enterprise systems for the purpose (from a NAM perspective) of providing data to support asset management analyses and decision-making. Due to the comprehensive nature of CMMS applications, it was only possible to conduct a very cursory review of the application using literature available from the supplier. Additionally, due to the significant costs involved with installation / replacement of a CMMS, it is not anticipated that plant operators would consider replacement of these systems except within the context of the execution of a broad information technology enhancement strategy. Thus, from a NAM Toolkit perspective, individual plants / fleets would need to conduct evaluations of the installed CMMS for its capabilities, from which a plant / fleet unique gap analysis would need to be conducted.

Reliability Engineering Tools

Because NAM and equipment reliability (ER) are closely coupled, the evaluation of the impact of various decision alternatives on plant operational and safety performance is an important component of AP-940. In particular, these evaluations are necessary components of the following process steps in AP-940:

- Generation Planning step 3.2.2
- Project Evaluation and Ranking steps 3.3.1 and 3.3.2
- Long Range Planning steps 3.4.1 and 3.4.3
- Plant / Fleet Valuation step 3.6.3

Unlike the CMMS application described above, reliability engineering tools support specialized analyses; thus these tools would most likely only be utilized by personnel with expertise in this discipline. On the other hand, reliability engineering is a recognized engineering sub-discipline with several professional societies and academic journals dedicated to the furtherance of the state of art.

Due to the specialized and technical nature of the reliability engineering discipline, it was anticipated that there would be a limited number of COTS products available to support these requirements. This expectation was confirmed via the internet search where seven potential tools were identified. Note that for this evaluation, only COTS tools were included; no attempt was made to survey and classify tools developed by EPRI that support reliability evaluations of nuclear plant structures, systems and components (SSC's). Based on this search, one candidate was selected for a more in-depth evaluation. This tool consisted of an integrated suite of reliability and statistical analysis tools that operate as a third party software package. This tool was selected because it has been applied in numerous applications in multiple industries including nuclear power applications. Other applications for which the selected tool has been applied include the defense, aerospace, process and petrochemical sectors. The software selected also is ISO-9000 certified. This application software supports the following analysis functions:

- Fault tree / event tree modeling
- Reliability block diagram (RBD) and Markov modeling capability
- Failure modes, effects and criticality analysis (FMECA) capability
- Life cycle cost analysis
- Failure reporting and corrective action tracking (FRACAS)
- Statistical data analysis and reliability and maintainability prediction

Due to the extensive downloadable literature available, a fairly comprehensive preliminary assessment of the application tool could be conducted. In addition, a downloadable demo version is available for more comprehensive evaluation. However, this was not investigated as part of this study.

Decision Analysis Tools

Decision analysis is an important element in the conduct of asset management. Numerous AP-940 process steps are designed to obtain intermediate and final decisions in the NAM process. In particular, AP-940 is structured to require formal decisions in each of the following processes:

- Strategic Planning steps 3.1.2, 3.1.3 and 3.1.4
- Project Evaluation and Ranking step 3.3.2
- Long Range Planning step 3.4.2
- Plant / Fleet Valuation steps 3.6.2 and 3.6.3

Similar to reliability engineering, decision analysis is recognized as a formal sub-discipline of operations research with a professional society and academic journals dedicated to the furtherance of the state of art. In this regard, the Institute for Operations Research and Management Science (INFORMS) website provided a single "one stop shopping" capability to conduct this review [4]. An important item identified via this search was that the society conducted a survey in 2004 of vendors that provided decision analysis services and software tools. A review of this survey [5] identified 24 COTS tools available from various vendors. In addition, this survey provided a classification of the capabilities of each of the identified tools and displayed the results in a matrix format. It is important to note that this level of detailed information was not found for any of the other applications for which a preliminary evaluation was conducted.

The candidate decision analysis tool selected for a more in-depth evaluation consisted of an integrated suite of decision and statistical analysis tools that operate as add-in toolbars / menus in Microsoft Excel. The application software supports the following analysis functions:

- decision tree and inference diagram modeler
- Monte Carlo analysis with decision tree linking capability
- sensitivity analyses
- data fitting to numerous statistical distributions
- neural network and genetic algorithm capability

Due to the on-line tutorial, a fairly detailed preliminary assessment of the application tool could be conducted in a relatively short time (e.g. approximately one day).

Summary Conclusions

For all of the applications evaluated, appropriate COTS applications software could be identified with a moderate amount of effort using commercially available internet search engines. However, for two of the three applications surveyed, a large number of software packages were identified that potentially could perform the desired functions. In addition, this survey was not complete in that it did not identify all applications for these functions; for example, some tools known to be in use at commercial nuclear plants were not found in the searches that were performed. Additionally, none of the tools that were identified performed all or even a significant fraction of the NAM process elements identified in AP-940. Thus, the market for these tools is fractured into many providers that only address portions of process. Additionally, the large number of COTS tools that were identified precludes identification and evaluation of the entire spectrum of possibilities. Thus, any attempt to develop and evaluate a complete catalog of tools will not achieve the short term NAM implementation objectives of operational nuclear plants. This conclusion resulted in the decision to leverage utility experience to limit the search to the identification and evaluation of tools currently in use at operating plants. From this assessment, a gap analysis could be conducted to determine the current needs of these plants and, upon prioritization of these needs, focus near-term research to addressing the most important of them.

2

PURPOSE AND DESIGN OF SURVEY OF TOOLS IN USE AT OPERATING NUCLEAR PLANTS

Based on the results of the preliminary review of existing tools for the limited set of NAM functions described in Section 1.2, it was determined that any attempt to comprehensively identify and evaluate tools to support the AP-940 functions would not be a useful endeavor. The following factors lead to this conclusion:

1. The market is fractured into many providers of tools that address portions of the NAM process. No single source exists that addresses all (or even a significant fraction) of the functions necessary for effective and efficient NAM decision-making.
2. The large number of COTS tools that address various NAM functions precludes identification and evaluation of the entire spectrum of possibilities.
3. The pace of technological change and product life-cycle associated with many of the tools is too rapid to permit their effective evaluation. By the time a detailed assessment of the tool capabilities could be conducted, new versions of the software with enhanced capabilities often are released.
4. In many cases, existing COTS tools possess significant capabilities and sophistication and can meet the functional needs of the associated AP-940 functions.

Based on these conclusions, subsequent discussion with industry representatives indicated that the key to furtherance of industry capabilities should be to focus on improvements in the processes used in NAM. In this context, software tools simply enable the effective and efficient execution of the processes.

As a first step in this effort, it is necessary to identify the processes and tools that currently are used by nuclear operating companies for execution of NAM. From the perspective of the NAM Toolkit, an efficient method to accomplish this initial objective was determined to be to conduct a survey of personnel responsible for NAM within their respective organizations. The purpose of this survey was to identify the suite of tools currently being employed to support the various NAM functions identified in AP-940. In addition to identifying a representative sample of the tools currently in use, a second objective was to obtain an evaluation (by the user) of the applicability and effectiveness of each tool.

Since AP-940 was developed to serve as the standard process document that addresses NAM in the nuclear industry in the United States, a survey was developed to permit identification of the tools used to accomplish the functions specified therein. Thus, for each Level 2 process identified in the AP-940 NAM Process Model (see Table 1-1), a targeted set of questions was asked of each utility. These questions were intended to identify the tool(s) used to accomplish each function. Each utility then was requested to provide its assessment of the capabilities and applicability of the tool to meet the objectives of the organization. In the interests of obtaining a rapid turnaround to permit analysis of the data and generation of initial conclusions, the survey was structured so that the information could be obtained via phone interviews with responsible utility participants. If the answers to a particular question were not known by the respondent, follow-up was attempted to obtain the answer. Additionally, if multiple tools are used, separate answers were obtained for each.

The specific survey questions were as follows:

1. What tool(s) is used by the utility / plant to gather the required data and perform the analysis?
2. Is the tool(s) in use (a) commercial off-the-shelf (COTS), (b) EPRI developed, (c) utility (i.e. in-house) developed, (4) other (e.g. MS Excel Spreadsheet application).
3. What is the utility experience with the tool(s) with respect to:
   - technical adequacy,
   - user friendliness,
   - integrability with other tools in use at the utility (e.g. Are necessary inputs directly available or must they be manually obtained / entered?, Are outputs in a proper format for decision-making or for use in other tools?, etc.).
4. Provide a self-rating of the tool for purposes of classification and analysis. These ratings were structured to be classified into the following categories:
   - Tool meets all needs, no plans to change.
   - Tool meets most needs, but would consider migration if a better tool was identified / developed.
   - Tool useable but does not meet utility needs in one or more key areas; would benefit from identification / development of a better tool.
   - Tool does not meet utility needs; desire to migrate to another tool.
   - No tool available to perform function; need to identify / develop new tool.
5. Any comments the utility wished to provide associated with the tool, its capabilities or its usefulness.

These questions were posed to responsible NAM personnel at utility members of the EPRI NAM Advisory Committee. Responses to this survey are analyzed in Chapter 3 of this report. Summary conclusions and a proposed path forward are provided in Chapter 4.

3 ANALYSIS OF UTILITY SURVEY RESPONSES

Utilities that provided responses to the survey are listed in Attachment A. These utilities represent a cross section ranging from single unit sites to multi-unit fleets who participate in the EPRI Nuclear Asset Management Advisory Committee. Responses to the survey questions were as varied as the range of respondents and their organization's management philosophies. In most cases, more than a single respondent from each organization was required to obtain the desired input. This characteristic underlines the multiple attribute inputs required in the asset management process. It also underscores and reaffirms that asset management is driven by the particular business processes employed by the organization, and that the particular tools used only serve to support execution of the process.

With respect to managing nuclear plant assets, NEI AP-940, *Nuclear Asset Management Process Description and Guideline* Rev.0 [1] was developed to provide generic guidance to the industry. This guideline describes a comprehensive and standard process that enumerates the functions necessary to effectively implement a nuclear asset management program. The process descriptions provided in AP-940 establish a baseline for consistent nuclear asset management activities and is used in this document as the foundation for the assessment of the current "as found" tools used by the target population in their nuclear asset decision making process. Table 1-1 of this document provides a brief description of the AP-940 Level 1 and Level 2 functions. This survey was intended to provide a catalog of tools used by operating nuclear plants to achieve the identified AP-940 functions. In most cases, respondents did not identify specific tools to achieve the individual AP-940 Level 2 functions. In nearly all cases, the tools selected (or developed) were designed to implement the particular business process used by the utility. In the context of mapping these tools to the AP-940 functions, this can best be viewed as a roll-up of the Level 2 attributes into the higher level AP-940 Level 1 business process. Thus, the discussion of observations and conclusions from the survey are provided using the AP-940 Level 1 processes as the foundation. Where specific tools are identified for Level 2 attributes, they are highlighted in the analysis.

Strategic Planning (AP-940 Function 3.1)

As described in NEI AP-940, the primary task of strategic planning is to "distill the requirements of key stakeholders of the nuclear plant or fleet into a tangible set of actions or goals that maximize the plant's value to its stakeholders. This is accomplished by determining how the plant can best meet the needs of its stakeholders with its current resources and the constraints imposed upon it" [1].

In the survey, no specific tools were identified that captured the Level 1 and Level 2 elements in their entirety. Most respondents indicated that a business process was in place to drive completion of the basic functions. Some organizations indicated that Decision Support Systems (DSS) were used as enabling tools. For those utilities that participated in the survey and employed these tools, Artemis 7 and Primavera were identified as the software systems being used in this capacity. Because of the costs associated with implementation of these platforms, they typically were implemented by fleet operators with single site plants relying on in-house developed applications (typically employing applications developed from the Microsoft Office suite). In all cases, data were gathered to support the asset management decision process primarily via interviews with stakeholders such as executive and senior management and second line managers. From these data, gap analyses and benchmark analysis were conducted. At this level of decision-making, mission, vision, goals and objectives are determined by executive and senior level managers. Commercially available knowledge worker systems are used to distil the data into useable information. All of the respondents indicated that the Microsoft Office suite is extensively used in the form of in-house developed Excel spreadsheets and/or Access databases to transact the data for conversion into prioritized lists, charts, tables, benchmarks, metrics and reports to support the DSS. Some organizations reported that linkage between the knowledge support systems and the decision support systems is weak Data input and output requires many sources and iterative calculation subroutines that are time consuming when developing various scenarios and evaluating the sensitivity of the results to various variable factors.

The survey respondents identified the following tools were utilized to support the strategic planning function: *Artemis Portfolio Director* (Commercial DSS), *Primavera* (Commercial DSS), *Microsoft Office Suite* (predominantly Access, Excel, and Word), *Crystal Ball* (Microsoft Excel third party add-in for performance of Monte Carlo statistical analyses), *Business Objects* (third party report generator). For the most part, the utility respondents indicated the tools employed are capable of supporting the asset management decision process at their facilities. The majority of potential improvements were identified to be more related to the processes used to acquire and analyze the necessary information.

Generation Planning (AP-940 Function 3.2)

As discussed in AP_940, the generation planning process primarily "aligns the plant's outputs with the needs and demands of the market or utility system. The process also analyzes the impact of certain strategies on plant/fleet generation. This is accomplished by assessing the needs of the system and the generating resources available from the plant or fleet and then reconciling the two to develop a generation plan for the plant or fleet" [1].

Regardless of whether a single unit or an integrated fleet, commercial nuclear generators serve as base loaded generation for the electrical grid. Thus, the operational objective is to maximize generation (at the lowest possible cost). Where generators wield some level of decision-making discretion is in the outage and load reduction determinations. Even for this limited application, the contribution from generation planning typically is treated as an input provided to the analysis rather than as specific decisions to be made by the nuclear management organization. Thus, the survey respondents indicated load forecasting and planning was performed by organizations within the utility that are external to the management team responsible for asset management decisions (typically generation planning was identified as being performed at the corporate level). From the perspective of the personnel who responded to the survey, output from the generation planning analyses serve as input information for asset management decision-making at the plant and fleet level. One specific potential exception to this perspective is the decision whether to pursue extension of the plant operating license. However, in this application, political and other non-financial considerations provide a significant impact into the decision, with the ultimate decision made at the corporate level (e.g. utility board of directors). As a result of these characteristics, no specific tools that support this function were identified by the survey respondents.

Project Evaluation and Planning (AP-940 Function 3.3)

The objective of the project evaluation and ranking process, as described in AP-940, is "to establish priorities among competing uses of plant/fleet resources. The process receives inputs from project originators who conceive and propose projects and then prioritize and rank those projects according to the criteria developed by the strategic planning process. Several areas of the process are likely shared between the NAM process and other project originating processes such as Equipment Reliability. This allows projects from all originators to be integrated and prioritized together to ensure that consistent evaluation methods and selection criteria are applied throughout a plant or fleet. Therefore, some of the process steps described below could also be carried out as part of the project origination process (e.g. for equipment related projects an important origination process is the INPO Equipment Reliability Process (specified) in AP-913)" [1].

Business processes were identified as the prime drivers for this AP-940 Level 1 function and its corresponding supporting Level 2 elements. We note that, as discussed in Chapter 1 of this report, many of the specific RIAM functions are designed to provide details and address these AP-940 functions. As discussed with the utility respondents, both capital and expense projects above certain cost criteria typically are formally addressed by these processes. Project horizons were typically identified as one to five years with the latter primarily handled within the utilities long range planning process. Most respondents discussed short-term and long-term planning being conducted as part of either one integrated process or as part of two individual processes that are similar in structure and review / approval. In one case, a respondent indicated that the process was the same as that used for strategic planning. Tools included transactional support systems such as the Computerized Maintenance Management System (CMMS) for identification of equipment performance issues, action requests and project submission. A separation exists between some single unit and fleet operated utilities to the level of rigor their attendant project evaluation processes entail. Artemis and Primavera are used as the DSS for some of the fleet utilities; although these tools are not used exclusively (e.g. Excel, Access and in-house developed "stand alone" applications are also employed to aid in the project evaluation process).

In the evaluation of a potential portfolio of projects, utilities typically classify them as an aid in supporting the decision process. Regulatory commitment, asset repair, plant upgrade, plant improvement and generation growth are among the project categories for selection and evaluation that most commonly were identified by the respondents. In all cases, financial metrics such as net present value (NPV) and internal rate of return (IRR) are used as an input into the project approval decision. However, attributes that are not easily quantifiable typically are considered by some to varying degrees. However, in discussions with the utility participants, incorporating these elements into the decision process was identified as providing a significant challenge and the development of a standard and robust approach to address this issue represents a significant opportunity for improvement in the evaluation / decision process. Examples of some of attributes that impact NAM decisions are ALARA, nuclear safety, worker safety, plant facilities and corporate / regulatory goodwill. Project matrices, Microsoft Word documents, spreadsheets and lists are used extensively in support of many tiers of review and approval. The respondents indicated that many of the analyses are performed via "brute force" and that enforcing business process discipline was the critical success factor for addressing this aspect of asset management. Most survey respondents were satisfied with their current business practices and enabling tools for this AP-940 function. Improvement areas identified included better linkage between the knowledge worker systems and decision support systems, improved consideration and weighting of non-quantifiable attributes and factoring the impact of uncertainties (particularly as projects approach a bifurcation point or are close to the approve / defer / reject threshold). Finally, a significant concern of the respondents was in development of processes that ensure that the outcomes obtained were consistent and repeatable.

The survey respondents identified the following tools were utilized to support the project evaluation and planning function: *Indus Passport* (Integrated CMMS)*, Artemis*, *Primavera*, *Microsoft Office Suite* (predominantly Access, Excel, and Word), *Crystal Ball*, *Business Objects*, and *in-house developed applications.*

Long Range Planning (AP-940 Function 3.4)

The objective of the long range planning process is "to establish a multi-year baseline plan of action for the plant based on the plant's strategy, targets, and prioritization. The plan should include O&M, Capital, and Fuel activities and costs projected over the planning time horizon" [1].

Most respondents did not distinguish between long range planning and project evaluation in their business processes. Long range planning horizons varied from ten to thirty years. The tools utilized were the same regardless of the selected planning / evaluation timeframe. Because of the specificity of the attributes contained in this AP-940 Level 1 function, the respondents were capable of providing information at the Level 2 functional level in most cases.

Operations and maintenance cost planning (AP-940 Level 2 function 3.4.3) was predominately performed using evaluations conducted on spreadsheet applications developed to conform to the organization's specific business processes. Survey respondents indicated that they provided station estimates that generally were rolled up into corporate human resource planning systems. Typically, workforce plans (AP-940 Level 2 function 3.4.4) were developed at the corporate level, typically by the human resources organization. Microsoft Excel spreadsheets, Tempus (a commercial workforce planning tool), and home grown applications were identified as the tools used for these evaluations. However, since this function typically was performed at a corporate level, several respondents did not know the specific tool that was utilized for this function.

Similar to workforce planning, fuel planning (AP-940 Level 2 function 3.4.5) was predominately performed in organizations external to the organizations directly responsible for asset management (i.e. the personnel that were interviewed for this survey). Thus, the survey respondents could provide no feedback with respect to this function. However, the researchers note that due to the specialized technical nature of fuel planning, this function typically is performed by specialized personnel using highly specialized computer codes that were either developed in-house or are proprietary to the fuel supply vendor.

The effectiveness of the tools identified by the survey respondents was similar to that identified and discussed for the Project Evaluation function. Most of the respondent utilities used basic knowledge support system tools tailored to their situation and organizational processes. Most of the tools used for these functions have been in place for many years and the users were satisfied with them. Where a level of dissatisfaction was expressed, it was with their overall business processes employed (e.g. either in the effectiveness of the process or the level of effort required to implement it) and not with the specific tools.

The survey respondents identified the following tools were utilized to support the long-range planning function: *Indus Passport, Artemis*, *Primavera*, *Microsoft Office Suite*, *Tempus* (commercial workforce planning tool), *Crystal Ball*, *Business Objects*, and *in-house developed applications*.

Budgeting (AP-940 Function 3.5)

AP-940 defines the goal of the budgeting process is "to establish near term budgets for departments within the plant or fleet. The budgeting process is similar to the Long Range Planning process in its structure. The primary difference is that the Long Range Plan provides a plan for spending and action, while the budgeting process provides an authorization to spend or take certain actions. The budgeting process is also typically for a shorter time frame (1-2 years) and at a higher level of detail. The budgeting process takes actions in the long range plan as a baseline and adapts and adds detail to that baseline to reflect current targets" [1].

AP-940 function 3.5 generally parallels activities described in the Long Range Planning function. No specialized decision support system or knowledge work support system tools were identified by the survey respondents. Most of the budgeting activities are supported using spreadsheet applications developed by the individual utilities. In one case Primavera was utilized for the project budgeting function (AP-940 Level 2 function 3.5.5). Business processes were identified as the prime driver of the plant / fleet budgeting activities. The survey respondents indicated that EUCG data were used for competitive analysis. Labor estimating practices and processes were universally identified among respondents as areas requiring improvement over current methods.

The survey respondents identified the following tools were utilized to support the long-range planning function: *Primavera, Microsoft Office Suite,* and *Crystal Ball*.

Plant/Fleet Valuation (AP-940 Function 3.6)

AP-940 defines the objectives of the Plant / Fleet Valuation Process as follows: (this process) "estimates the baseline value of the plant or fleet to its stakeholders and evaluates changes to that value that result from different operating strategies. The primary outputs are a baseline plant value and a decision or risk analysis" [1].

Plant valuation was generally viewed by the respondents as a corporate portfolio management function. Business processes using spreadsheet applications (primarily developed in Microsoft Excel supplanted by the Crystal Ball add-in) were cited by several utilities as the foundation for plant/fleet valuation evaluations. One respondent used Aurora for market forecasting and sensitivity analysis. AP-940 Level 2 function 3.6.3 risk analysis/asset valuation was determined in one case using a Risk Informed Asset Management (RIAM) process while another respondent developed cash flows and ProForma information based upon an in-house developed application.

The survey respondents identified the following tools were utilized to support the plant / fleet valuation function: *Microsoft Office Suite* (Excel and Access)*, Crystalball, Aurora* (wholesale market forecasting tool)*,* and *in-house developed applications*.

4

PROPOSED PATH FORWARD

NEI AP-940 *Nuclear Asset Management Process Description and Guideline* Rev.0 [1] was developed as a nuclear industry guidance document to describe standard and consistent process attributes necessary for the effective conduct of asset management for nuclear utilities. In discussions with the utility participants in this survey, it became evident that NEI AP-940 generally is not well known by utility personnel. Many of the individuals who participated in the survey discussions, including some that were responsible for conducting asset management functions described in AP-940, were not aware of the documents existence. The document describes in the Level 1 and Level 2 functions what process elements should be included in a nuclear asset management program, but does not provide guidance in how they are to be implemented. Thus, processes that have been developed on how to implement the AP-940 functions are as varied as the organizational goals and objectives, management structure, operating philosophies and business objectives of the individual utilities. This is not unexpected due to the fact that many of these functions are required to run any enterprise and were put in place by nuclear operators long before AP-940 was developed. For similar reasons, the tools employed to implement the various process functions at different utilities are as varied also. While some areas for improvement were identified, most of the individuals who participated in the interviews expressed a relatively high degree of satisfaction with the tools used in their organizations. There was not an overall consensus of one best tool for any process; in fact, the survey results point to a relative satisfaction with the use of multiple tools to support the multi-faceted process. Respondents were more interested in identifying best practices employed throughout the industry (and in other process industries as well). This identification of best practices is envisioned to be used to improve their business processes and asset management philosophies.

Based on this information, a reasonable conclusion for the path forward lies not in what is the next best tool, but in the enhancement of the overall asset management process. To be successful, asset management demands sound financial modeling, operational due diligence and process execution discipline. We note that these elements for success are not due to characteristics unique to nuclear power applications; they are ubiquitous across all capital intensive industries with the basic principles well formulated in standard business texts. While some of the survey respondents were seeking best practices to benchmark, others were searching for process improvements to current practices such as improved consideration for non-quantifiable attributes, consistent standard evaluation practices that lead to equitable outcomes, evaluation of sensitivities surrounding uncertainties (especially as they approach bifurcation points), improvement in estimating practices especially relating to labor and tools to facilitate timely data input and output linkages with decision support systems.

Thus, the challenge going forward is to better understand the current nuclear asset management state of the art and explore potential improvements to it. To achieve this, it is important to understand not just practices employed in the nuclear power sector, but to evaluate and leverage best asset management practices employed in other business sectors that possess similar characteristics (e.g. capital intensive industries with significant levels of external regulation).

This survey provided a snapshot of some of the tools that are employed in the performance of asset management practices. There is no unique tool of choice, and given the nature of technology, tools currently used are likely to change rapidly. The basic conclusion from this survey serves to point out and reaffirm that the key to success is the business process that drives the many organizations, attributes, and tools employed in asset management. Thus, further research should focus on development of improvements in the process elements that support effective and robust asset management decision-making. As discussed in Section 1, the RIAM framework provides a practical construct from which improvements can be identified, evaluated and developed. Although this paradigm does not address all functions defined in AP-940, it does address the functions plant / fleet decision-makers routinely address and for which improvements in methods and processes would produce immediate benefits

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