

# Nuclear Industry Modernization— Modernization Technology Assessments

Specification and Template

3002020578

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**EPRI** Project Manager

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# ABSTRACT

The Plant Modernization Toolbox (PMTB) is a resource to facilitate decision making and execution of the modernization process at nuclear power plants (NPPs). The PMTB includes a compendium of Modernization Technology Assessments (MTAs), which cover a wide variety of candidate modernization improvements available for NPPs. The vision is for nuclear industry stakeholders to prepare MTAs describing their work to be published to the PMTB for the benefit of all NPPs pursuing modernization. This report provides guidance for preparing MTAs.

As part of the guidance, this report includes a template for an MTA, specifications for completing each field of the MTA, and the process for submittal and review of MTAs. Example MTAs are available on the PMTB website (<u>epri.com/nuclearplantmod</u>).

#### Keywords

Business case development Cost savings Modernization Technology Assessment (MTA) Plant modernization Process improvement Technology readiness

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# **1** INTRODUCTION

## Purpose

Envisioned as the process for transformational change in nuclear power plants (NPPs), plant modernization will achieve new efficiencies in multiple functional areas through the application of technology and innovation. The Electric Power Research Institute's (EPRI's) Plant Modernization Toolbox (PMTB) is a website that facilitates decision-making and execution of the modernization process. Development of the PMTB is ongoing, with the initial release in December 2020, new website features planned for 2021, and new content to be added from industry stakeholders in 2021 and beyond.

The PMTB includes a compendium of Modernization Technology Assessments (MTAs) that covers a wide variety of modernization improvements. This report provides guidance for industry stakeholders to prepare MTAs for incorporation into the PMTB.

## Background

Nuclear utilities are facing increased pressure to reduce operations and maintenance costs and make nuclear energy more economically competitive with other generation types. For NPPs that are several decades old, modernization is widely viewed as a potential avenue for increasing cost efficiency through effective use of technology and innovation.

The EPRI PMTB is an online database of potential modernization improvements with basic information to allow users to identify the most suitable improvements for their circumstances. The MTAs provide introductory content describing the subject technology, potential savings, costs for implementation, risks associated with implementing the technology, and a list of associated reference implementation guidance. The set of MTAs that appears in the PMTB draws from technology and process improvements that have already been implemented at operating NPPs.

The EPRI software *Business Case Analysis Model (BCAM) v2* (3002019454) was issued in 2020 [1]. The software includes a template for performing business case analyses of modernization improvements, and the user manual includes several worked examples for using the business case analysis template. With user-supplied inputs, the spreadsheet determines a net present value of proposed modifications that considers costs and the value of expected benefits. The BCAM software is available on the PMTB website, and several Technical Briefs of example BCAMs are available for different modernization improvements.

The EPRI report *Nuclear Power Plant Modernization—Strategy Development and Implementation Process* (3002018428) describes a process for systematic implementation of modernization at nuclear utilities [2]. This process is comparable to other utility changes that required a wide range of supporting activities (for example, up-rates and license renewal). Figure 1-1 provides a summary description of the elements of the modernization process.



Figure 1-1 Summary of elements for modernization process

## Scope

This report provides detailed guidance for developing MTAs. Section 2 describes MTAs and provides general directions for preparing them. Examples of completed MTAs can be found on the PMTB database (<u>epri.com/nuclearplantmod</u>).

# **2** MODERNIZATION TECHNOLOGY ASSESSMENTS

## **MTA Functional Requirements**

The purpose of an MTA is to provide basic information on a potential process improvement or technology so that the reader can quickly understand the concept and screen for whether further consideration is warranted. The functional requirements for MTAs are as follows:

- Describe the modernization improvement at a summary level (appropriate for a technical manager reader).
- Describe the problem that the improvement is intended to solve.
- Describe the costs and benefits at a conceptual level.
- Provide references to additional documentation to support any further evaluation needed during the initial screening and to provide a pointer to installation guidance or other information that would support eventual implementation.
- Provide an EPRI point of contact who can provide additional information on the technology improvement and previous implementation examples.
- Identify risks associated with the improvement and any other details that are significant enough to potentially impact decision making on whether to pursue the improvement.
- Use a standard format to facilitate searchability and usage in the database.
- Include concise narrative in data entry fields to facilitate fast review.

## **MTA Content Requirements**

Based on the purpose of MTAs and the functional requirements previously described, all MTAs should satisfy several screening criteria, as follows:

- The MTA will be publicly available; therefore, any confidential or proprietary information cannot be included.
- The improvement must be fully developed and already implemented at an operating NPP. The PMTB should not include MTAs for in-flight research or development projects. Regulatory compliance concerns with a potential improvement are not disqualifying for development, but these concerns should be identified as risks.
- The modernization improvement must be applicable to more than one NPP. The technology should not be specific to a single plant and should be applicable across different utilities. Improvements developed for a specific plant (such as software or process methodologies) that can be adapted to fit other NPPs are acceptable.
- For technologies provided by a vendor, there must be more than one vendor option or a reasonable ability for a utility to develop the technology or method with similar functionality. MTAs published to the PMTB webpage must not be a tacit endorsement for a particular vendor.

• Implementation guidance must be available. Ideally, such guidance would be in the form of published and publicly available documentation (such as an industry publication, an EPRI report, or a research technical paper). If the implementation guidance was prepared by another organization, such as a Nuclear Energy Institute (NEI) TIP Award, permission from the authoring organization must be granted before being included in the MTA. Documentation of implementation guidance might not be publicly available in every case (such as for plant modification packages). In these cases, the implementation guidance field should point to the EPRI contact who can provide additional information, potentially including a utility point of contact. Vendor literature might not be cited as implementation guidance.

## **Process for Preparing and Reviewing MTAs**

The process and mechanics for preparation, review, and acceptance of MTAs into the PMTB includes the following steps for the MTA preparer and EPRI:

- 1. Select a topic for the MTA (see the PMTB Modernization Technology Assessments webpage for previous examples).
- 2. Verify that the MTA Content Requirements (see the preceding section) are satisfied and that the scope of the topic is appropriate for an MTA.
- 3. Inform EPRI (<u>NuclearPlantMod@epri.com</u>) of your intent to prepare an MTA and identify the topic. EPRI will acknowledge the new MTA and might provide insights to help shape content (for example, regarding other MTAs that are in preparation or already exist on that topic or similar topics).
- 4. Prepare a draft MTA using the MTA template (see Appendix A) and associated guidance for completing each field.
- 5. Submit the draft MTA to EPRI by email for stakeholder review (NuclearPlantMod@epri.com). Submit the draft in the form of a Word document (.docx) to allow reviewers to edit directly where appropriate. EPRI will review the draft MTA for consistency with the intent of the purpose of the PMTB and consistency with the template. The review will also check for obvious errors (such as updated or new information, including industry or regulatory guidance, or identification of incorrect references). However, the EPRI review is not intended to be a detailed technical or editorial review of the MTA content. EPRI will coordinate this review phase with the appropriate EPRI subject matter expert and other stakeholders, as necessary.
- 6. EPRI will provide any stakeholder comments to the MTA preparer. The preparer will address stakeholder comments and submit updated draft MTA with comments resolved to EPRI through email.
- 7. Once the MTA preparer and EPRI are in agreement on the inclusion of the MTA in the PMTB, the EPRI MTA lead will complete an internal review for quality and public access requirements and have the MTA reviewed by EPRI management. Completed review forms for each MTA will be stored in accordance with EPRI practices.
- 8. The final MTA is uploaded to the PMTB website after EPRI review.
- 9. The MTA preparer and EPRI should validate the content and appearance of the final published MTA on the PMTB database.

### **MTA Specification**

To facilitate development of MTAs, a template is presented in Appendix A of this report. The template includes guidance on how to fill out each field and suggested generic wording where appropriate.

The template draws on the Shelfware Extraction and Elimination Process (SWEEP) scores in the EPRI report *Technology and Process Improvement Readiness and Proposed Measurement Method for Nuclear Plant Modernization* [3]. This report contains additional details and examples of applying SWEEP scores to a variety of improvements. A table describing the SWEEP score ratings is provided in Appendix B.

Some process improvements/technology do not have direct efficiency benefits themselves but are needed to enable other process improvements/technology that do have cost-savings benefits. These items are referred to as *enablers*. For enablers, the savings will normally be low, but reference is made to other process improvements/technology that do have savings. As an example, installing a wireless infrastructure is an enabler. Electronic work packages and online monitoring are two example applications that require or are made more efficient by a wireless infrastructure.

# **3** REFERENCES

- 1. *Business Case Analysis Model (BCAM) v2.0*. EPRI, Palo Alto, CA: 2020. 3002019454. (software program)
- 2. Nuclear Power Plant Modernization—Strategy Development and Implementation Process. Software program) EPRI, Palo Alto, CA: 2019. 3002018428.
- 3. Technology and Process Improvement Readiness and Proposed Measurement Method for Nuclear Plant Modernization. EPRI, Palo Alto, CA: 2019. 3002015802.

# **A** MTA TEMPLATE

This appendix contains the template for MTAs that will populate the PMTB. The text in the template in Table A-1 is provided for guidance to complete an MTA. A blank template is shown in Table A-2 and provided with this report as an editable Microsoft Word attachment.

#### Table A-1 MTA template with guidance

MTA Number	<b>MTA-[Insert functional area abbreviation]-[Sequence number TBD by EPRI]</b> The MTA number includes the functional area that is expected to benefit most from implementation of the modernization improvement (see Functional Area Where Benefits Will Be Realized field below). The functional area abbreviations listed in the table of the last page of the MTA template (see Table A-3) should be used for this insert to the MTA identification number. EPRI will populate the sequence number at the time of publication. An example MTA number to be submitted with a draft MTA is "MTA-OP-TBD."	
Title		
The title should start with the problem (such as "gas void detection") and be followed by a short technology solution name (such as "wireless ultrasonic monitoring"). This approach for titles was selected because the end-users of the PMTB (that is, utilities) will often be thinking of modernization improvements in the context of the problem they are trying to solve. A title that reflects only the name of the improvement solution might be less effective because the end-user might not be familiar with the improvement or its purpose. Titles should be succinct—on the order of 15 words or fewer. Succinct titles support rapid screening of MTAs by utility personnel for interest and feasibility.		
Description		
The purpose of this field is to provide a complete statement of the problem and the solution for the reader who was interested by the title and is seeking further information. This is also used to summarize options or variants of the solution that are important for understanding the full scope of the MTA. Technical details should be included to provide the reader enough information to understand the improvement but at a high enough level to allow for quick screening. This field should be a few paragraphs at most. If more narrative is needed, the MTA preparer should consider whether multiple MTAs (for example, each describing one of several variants) are appropriate		
Benefits		
Benefits Estima	te Because the main purpose of modernization improvements is to realize cost savings, the potential cost savings impact per year should be characterized in this field. Specific quantitative cost savings will vary between utilities due to differences in circumstances, so this field is intended only to provide a general sense of potential cost savings. If a modernization improvement is selected for further development, the subsequent business case analysis will provide a site-specific quantitative analysis.	

Benefits	
Benefits Estimate (continued)	The EPRI report <i>Technology and Process Improvement Readiness and</i> <i>Proposed Measurement Method for Nuclear Plant Modernization</i> (that is, the SWEEP Score report) ( <u>3002015802</u> ) provides several levels of approximate cost savings that should be used for differentiation. The appropriate level should be provided in this field. Savings levels are as follows:
	<ul> <li>Level 0 – Savings are not evaluated because the technology or process improvement is an enabler. An enabler is an improvement that does not inherently produce cost savings but permits implementation of other improvements. An example of an enabler is a wireless network.</li> </ul>
	<ul> <li>Level 1 – Savings are less than \$1 million per year.</li> </ul>
	<ul> <li>Level 2 – Savings are between \$1 million and \$5 million per year.</li> </ul>
	<ul> <li>Level 3 – Savings are greater than \$5 million.</li> </ul>
	In addition to the savings level, further savings information can be included to provide more detail on the potential savings benefits. Additional savings details might be presented as an approximate range within the SWEEP levels, but not a specific value.
	Avoidance of failures cannot be included as a quantitative cost saving for the purpose of assigning a level but can be cited as a potential benefit. As an example, an improvement in this case could use wording such as "significantly greater cost savings could be realized through crediting avoidance of reactor trips."
Benefits Description	To provide additional details on the potential benefits, this field should include a bulleted list of specific benefits and any associated quantitative estimates that are readily available, presented as a range or rounded estimate. For example, a potential benefit might include reduction of annual preventive maintenance costs by ~50%. It is not expected that MTA preparers will perform studies of benefits solely for the purpose of completing the MTA. If a quantitative estimate of the specific benefit is not available, none should be provided.
	The preparer of the MTA should consider the following areas that could benefit from the modernization improvement (this list is not exhaustive):
	<ul> <li>Utility labor (for example, reduction of time/effort required).</li> </ul>
	<ul> <li>Utility personnel safety (for example, reduction in personnel dose).</li> </ul>
	<ul> <li>Contracted services (for example, reduction of services required).</li> </ul>
	<ul> <li>Equipment/material/inventory changes (such as use of less expensive equipment or material; ability to maintain lower inventory; avoid cost growth due to large-scale parts/component/subcomponent obsolescence).</li> </ul>
	<ul> <li>Investment deferral (future expenses have lower net present value).</li> </ul>
	Quantifiable power output/thermal performance benefits.
	Work process efficiencies (for example, automated processes).
	<ul> <li>Other less quantifiable or semi-quantifiable benefits, such as uncertainty reduction, reliability improvement, increased safety margin, and benefits to key performance indicators.</li> </ul>

Benefits	
Benefits Description (continued)	For enabling improvements, list other potential cost-saving improvements that would benefit from the enabler (for example, a wireless infrastructure enables remote online monitoring to reduce maintenance costs).
Costs and Schedule	
Cost	Specific quantitative costs will vary between utilities due to differences in circumstances, so this field is intended only to provide a general sense of potential implementation costs. If a modernization improvement is selected for further development, the subsequent business case analysis will provide a site-specific quantitative analysis. The EPRI report <i>Technology and Process Improvement Readiness and Proposed Measurement Method for Nuclear Plant Modernization</i> (the SWEEP Score report) ( <u>3002015802</u> ) provides several levels of costs that should be used for differentiation. The appropriate level should be used in this field. Cost
	levels are as follows:
	Level 2 Implementation cost is between \$1 million and \$5 million
	<ul> <li>Level 2 – Implementation cost is less than \$1 million</li> </ul>
	Once the cost level is provided, further cost information can be included to provide more detail on the implementation costs. Additional cost details should be presented as an approximate range and not a specific value. The implementation cost assumes that any prerequisite enabling technologies are installed and used. Recurring costs can also be provided as additional information.
Schedule	This field characterizes how soon the utility might expect the improvement to be completed. This field should include the minimum expected schedule (duration) time for implementation of the subject modernization concept, using the following categories:
	Less than six months
	Six months to one year
	One to three years
	More than three years
	The entry in this field should presume that there is committed project engagement from initiation to implementation (such as release to operations). Other assumptions needed to explain the rationale for the stated schedule time should be included in this field.
Scope Context	<ul> <li>This field allows the preparer of the MTA to characterize the basis for cost, benefit, and schedule information. This information could be provided on the basis of performing the modernization improvement one time or multiple times (such as for one component at one particular site or for sets of components across a utility fleet). Example entries in this field include:</li> <li>Component/system</li> <li>Unit</li> <li>Site</li> </ul>
	Fleet

Costs and Schedule		
Scope Context (continued)	Any additional basis for the cost, benefit, and schedule information can be described in detail in this field. If applicable, the context should specifically identify if the basis for the information is a pilot or first-of-a-kind implementation.	
Risks		
<ul> <li>This field identifies high-level, significant risks that could threaten the success of implementing the modernization concept. These risks might arise from various factors (for example, dependencies on other enabling technologies) that can result in schedule delays or roadblocks, which might result in significantly increased project costs. Sources of risk to consider include the following:</li> <li>Cybersecurity</li> <li>Electromagnetic compatibility</li> <li>Technology prerequisites and limitations</li> <li>Health and safety</li> <li>Internal administrative challenges</li> <li>Risks should be written to describe the impact of the risk followed by the risk mitigation strategy and any applicable references (such as EPRI guidance). Any key lessons learned from previous implementations or similar modernization concepts can be included here.</li> <li>If no major risks or significant challenges are associated with the subject modernization concept, state "No unique risks beyond standard project risks associated with implementing changes at nuclear power</li> </ul>		
Administrative Items		
Date	This field contains the date that the final version of the MTA is approved and uploaded to the PMTB website. EPRI will populate the date at the time of publication. Write "TBD" in this field.	
Functional Area Where Benefits Will Be Realized	<ul> <li>This field should include the top three functional areas at a utility that are expected benefit most from implementation of the modernization improvement. If fewer than three areas will realize significant benefits, list only the applicable areas.</li> <li>A list of functional areas is provided at the end of this appendix. Functional areas should be listed in order of the most benefit realized to the least benefit realized as shown in the example below:</li> <li>Engineering</li> <li>Maintenance</li> <li>Operations</li> <li>The functional area that is expected to realize the most benefit will be used in the MTA naming convention.</li> </ul>	

Administrative Items	
Reference Implementation Guidance	This field should include reference information for implementation guidance for the subject modernization concept. If a reader selects the subject modernization item for further development, this guidance will provide an important resource for subsequent steps in the modernization process. Preferably, content for this field is published, publicly available documentation with a specific document number, revision number, and/or date that can be explicitly referenced. Such guidance can be in the form of a technical report or industry publication. For industry guidance or documents prepared by other organizations, such as an NEI TIP Award, the preparer must receive permission from the authoring organization before being included in the MTA. Hyperlinks to implementation information are ideal. EPRI cannot endorse a vendor-specific technology; therefore, vendor literature should not be included. In addition, MTAs cannot specifically identify usage at a particular plant, so citations to references that include the plant name should not be used.
	Implementation guidance can come from nonpublic sources of information, such as a utility modification package. Such information cannot be cited directly in the MTA. In this case, the reader would reach out to EPRI through the provided contact information (see field below) to obtain reference information.
Industry SME	This field will include an EPRI SME for the MTA subject. This will be determined by EPRI on initial review of the MTA. Write "TBD" in this field for the initial draft.
Previous Implementation	This field should point readers to contact EPRI for previous implementation examples. In this field, use generic wording such as "This improvement/ methodology has been implemented at a/several nuclear plant/s. Please contact the EPRI SME for additional information." When the original draft of the MTA is submitted to EPRI, the preparer should provide information to EPRI about where the improvement has been
	implemented to demonstrate that this prerequisite is satisfied.
Enablers	required for the subject modernization concept. Some modernization concepts might require an enabling technology, infrastructure, or process that the reader should understand when assessing the feasibility of the subject modernization improvement. For example, the Gas Void Detection Through Wireless Ultrasonic Monitoring MTA describes installation of wireless ultrasonic sensors and associated equipment. However, a wireless infrastructure, such as one provided by WiFi access points or a distributed antenna system, is a necessary enabling technology. If the enabling technology is a published MTA, cross-reference the MTA by MTA number and title. If there are no enablers, write "N/A."

Administrative Items	
SWEEP Score	The SWEEP score is a grading metric for an overall level of readiness for implementation of a given modernization initiative or concept, introduced in the EPRI report <i>Technology and Process Improvement Readiness and Proposed Measurement Method for Nuclear Power Modernization</i> (3002015802). The SWEEP score is broken down into six individual categories:
	• Cost
	Savings
	Payback period
	Licensing readiness
	Technology readiness
	Implementation proficiency
	The SWEEP scores for Cost and Savings should already be provided in the Cost and Benefits Estimate fields, respectively, of the MTA template and should be copied to this field for completeness. The scoring criteria for each category are provided in Appendix B and described in detail in the EPRI report 3002015802. This field should include the SWEEP score broken down into each individual
	category. A brief description or basis for each category's score can be provided, as necessary.
Applicability	Modernization concepts might have limited applicability based on the type of reactor or geographic region. This field should identify any such applicability limitations. The reactor type applicability might include specifying "BWR," "PWR," "LWR," "PHWR," or "other." If there are no limitations on applicability, the region/country and reactor type applicability should be "All reactor types" on one line and "All geographic regions" on the following line.
Keywords	This field should be populated with keywords that can be used to easily search for the subject modernization concept.
Business Case Analysis Cross- Reference	This field should cross-reference any completed business case analysis that uses this MTA (reference EPRI report 3002019454). If there is no completed business case analysis for this MTA, write "N/A."

#### Table A-2 Blank MTA template<sup>1</sup>

MTA Number MTA-FU	NCTIONAL AREA-SEQUENCE
Title	
Description	
Benefits	
Benefits Estimate	
Benefits Description	
Costs and Schedule	
Cost	
Schedule	
Scope Context	
Risks	
Administrative Items	
Date	
Functional Area Where Benefits Will Be	
Realized	
Reference Implementation Guidance	
Industry SME	
Previous Implementation	
Implementation Enablers	
SWEEP Score	Cost – Level
	Savings – Level
	Payback – Level
	Technical Readiness – Level
	<ul> <li>Licensing Readiness – Level</li> <li>Implementation Proficiency – Level</li> </ul>
Applicability	
Keywords	

<sup>&</sup>lt;sup>1</sup> This MTA can be accessed from <u>http://www.epri.com/nuclearplantmod</u>.

Table A-3 lists the functional area abbreviations to be used in the MTA numbering scheme (for example, *MTA-OP-1*).

## Table A-3

Abbreviations for MTA n	numbering scheme
-------------------------	------------------

Functional Area	Abbreviation
Operations	OP
Maintenance	MA
Work Management	WM
Radiation Protection	RP
Chemistry and Environmental	СҮ
Engineering	EN
Training	TR
Performance Improvement	PI
Corrective Action Program	CA
Security and Access Protection	SY
Procedures	PR
Emergency Preparedness	EP
Licensing and Regulatory Affairs	LS
Organizational Effectiveness	OR
Nuclear Oversight/CFAMs	NO
Lab Services	LB
Nuclear Fuels	NF
Probabilistic Risk Analysis	PRA
Records Management	RM
Quality Control	QC
Employee Concerns	EC
Fire Department	FD
Warehouse	WR
Information Technology	IT
Supply Chain	SC

This MTA can be accessed from <u>http://www.epri.com/nuclearplantmod</u>. For more on MTAs, see the EPRI report *Nuclear Industry Modernization—Modernization Technology Assessments: Specification and Template* (3002020578).

# **B** SWEEP SCORE CRITERIA

#### Table B-1 SWEEP score criteria [3]

SWEEP Score Key	Description	Level 0	Level 1	Level 2	Level 3
Cost	The estimated cost to implement the technology. It is assumed that existing enablers are installed and used as required.	N/A	Implementation cost is greater than \$5 million.	Implementation cost is greater than \$1 million but less than \$5 million (inclusive).	Implementation cost is less than \$1 million (inclusive).
Savings	The estimated savings, with priority given to measurable savings over the savings gained by event avoidance.	Savings are not evaluated because the technology or process improvement is an enabler.	Savings are less than \$1 million per year (inclusive).	Savings are greater than \$1 million per year but less than \$5 million per year (inclusive).	Savings are greater than \$5 million per year.
Payback	Evaluating the cost of implementation against savings assists in estimating the return on investment if the technology is implemented.	No identified payback period because either the savings were achieved by event avoidance or the technology or process improvement is an enabler.	Payback period is greater than five years.	Payback period is greater than one year but less than five years (inclusive).	Payback period is less than one year (inclusive).
Technical Readiness	The technical readiness level (TRL) is based on the formal nine-level taxonomy model developed by NASA. The purpose of the TRL is to estimate what has been achieved for a given technology and to track its development.	The technology is a concept only.	The technology is ready for detailed design and development.	The technology is ready for pilot deployment.	The technology is ready for wide operational deployment.
Licensing Readiness	This licensing readiness level is an estimate of the level of effort required to allow the implementation of the technology from a regulatory standpoint (United States).	National law changes are required for implementation.	Regulatory changes are required for implementation.	Regulatory guidance changes are recommended for implementation.	No changes are required for implementation.
Implementation Proficiency	Many of the technologies that could be leveraged by plant modernization require digital components. This means that a site should have a level of maturity to implement each of the technologies.	The technology should be implemented by sites that are considered centers of digital excellence.	The technology should be implemented by sites that specialize in digital integration.	The technology should be implemented by sites that use a systems engineering process when integrating digital technology.	The technology can be implemented by all sites, regardless of digital experience.

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