



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 28, 2021

Dr. Rita Baranwal
Vice President and Chief Nuclear Officer
Electric Power Research Institute
1300 West W.T. Harris Blvd.
Charlotte, NC 20262

Dear Dr. Baranwal:

Please find enclosed the signed Memorandum of Understanding (MOU) and Addenda between the U.S. Nuclear Regulatory Commission's Office of Nuclear Regulatory Research (NRC/RES) and the Electric Power Research Institute (EPRI) on Cooperative Nuclear Safety Research. The enclosed MOU renews our 2016 agreement and continues our cooperative nuclear safety research in multiple technical areas. The Addenda to the MOU outline the specific nature of our cooperation in these technical areas.

The MOU and Addenda were developed through collaboration between the staff of NRC/RES and Mr. Brian Burgos of your staff. Our two organizations have worked well together over many years, and I believe the cooperation has been mutually beneficial. We look forward to many more successful years for this partnership.

If you have any questions, please feel free to contact Mr. Nicholas DiFrancesco of my staff at 301-415-1115.

Sincerely,

A handwritten signature in black ink that reads "Raymond W. Furstenau".

Raymond Furstenau
Director of Nuclear Regulatory Research

Enclosures:

1. MOU between NRC and EPRI
2. Table of Updated and Renewed Research Addenda
- 3 – 8. Research Addenda

September 28, 2021

Dr. Rita Baranwal
Vice President and Chief Nuclear Officer
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Raymond Furstenau
Director of Nuclear Regulatory Research

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DISTRIBUTION:

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ADAMS Accession No.: ML21263A196

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DATE	09/20/2021	09/20/2021	09/23/2021	09/23/2021
OFFICE	RES/DE/DSA	OGC	RES/D	
NAME	KWebber	RBaum (NLO)	RFurstenau	
DATE	09/24/2021	09/21/2021	09/28/2021	

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MEMORANDUM OF UNDERSTANDING
between
U.S. NUCLEAR REGULATORY COMMISSION
and
ELECTRIC POWER RESEARCH INSTITUTE, INC.
on
COOPERATIVE NUCLEAR SAFETY RESEARCH

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) and the nuclear power industry (Industry) each conduct research on nuclear reactor safety and security. The NRC's Office of Nuclear Regulatory Research (RES) conducts independent research in all areas regulated by the NRC including ongoing and potential safety and security issues, risk-informed and performance-based regulation, and operating experience analysis. The Electric Power Research Institute, Inc. (EPRI) is engaged in research and development in the public interest and on behalf of Industry with respect to the production, transmission, distribution, and utilization of electric power including research designed to improve the safety and security, reliability, and economy of nuclear power plants. Although the research efforts of the NRC and EPRI may be conducted for different purposes, the underlying data and the results obtained have common value to both the NRC and EPRI. Accordingly, to conserve resources and to avoid unnecessary duplication of effort, both the NRC and EPRI agree to cooperate in selected research efforts and to share information and/or costs related to such research whenever such cooperation and cost sharing is appropriate and mutually beneficial.

This Memorandum of Understanding (MOU) is authorized pursuant to Section 31 of the Atomic Energy Act. The roles, responsibilities, terms, and conditions of this MOU should not be interpreted in a manner inconsistent with, and shall not supersede, applicable Federal laws and regulations as well as EPRI's status as a 501(c)(3) scientific research organization for the public benefit and the NRC's status as an independent regulatory agency.

This MOU describes the parameters within which cooperative research programs between the NRC and EPRI will be considered and conducted. Individual cooperative research programs are described in the addenda to this document ("Cooperative Research Programs").

PRINCIPLES OF COOPERATION

Article 1 - Responsibility of the Parties

- 1.1 Organizational Accountability within the NRC and EPRI. This MOU will be implemented by RES on behalf of the NRC and by EPRI's Nuclear Power Sector (NPS) on behalf of EPRI. RES and NPS are responsible for conducting cooperative research with third parties in the field of nuclear energy for the NRC and EPRI, respectively.
- 1.2 Contacts. The NRC's Senior Management Contact shall be the Director, Office of Nuclear Regulatory Research, and EPRI's Senior Management Contact shall be its Chief Nuclear Officer (Senior Management Contacts). The NRC and EPRI will each identify their respective overall coordination contacts to serve as the primary interfaces for routine interactions between the NRC and EPRI.

1.3 Management of Cooperative Research Programs

- a. Meetings. The Senior Management Contacts will confer, either via conference call or in meetings¹ as needed throughout the year, but will formally meet a minimum of once each year to exchange views on the strategic direction of the respective research programs and to identify opportunities to enhance cooperation. On a periodic basis, normally semiannually, the Senior Management Contacts will confer to identify areas of cooperation warranting greater management attention and to resolve any conflicts. The Senior Management Contacts shall agree on the priority, terms, and conditions of new Cooperative Research Programs and shall provide direction on ongoing work and other matters, as necessary. The Overall Coordination Contacts and appropriate Cooperative Research Program personnel may meet more frequently as necessary to manage the Cooperative Research Programs.
- b. Selection of Potential Cooperative Research Programs. The NRC and EPRI shall identify potential Cooperative Research Programs that are of benefit to the public and of interest to the NRC and the Industry. Factors to be considered when selecting potential programs shall include:
- Mutual interest in the subject matter.
 - Applicability of research results.
 - Contribution to plant safety and security.
 - Impact upon risk reduction.
 - Opportunity to leverage resources.
 - Timeliness.

Once an area of potential cooperative research is identified, a Cooperative Research Program may be pursued if mutual agreement is reached on the technical requirements of the project including objectives, scope, approach and quality assurance requirements, and the roles and responsibilities of each party.

- c. Documentation of Cooperative Research Programs. Once approved by the Senior Management Contacts, each Cooperative Research Program will be documented in an Addendum to this MOU. Each Addendum shall set forth in detail the goals and objectives of the Cooperative Research Program, the scope of work to be performed or undertaken by the NRC and EPRI, and, as appropriate, specifics regarding intellectual property allocation, use rights and confidentiality, the contractors to be employed, the technical requirements, the financial responsibility and resource commitment of the NRC and EPRI, and the anticipated schedule. On an “as needed” basis, the Parties may agree to make an Addendum legally binding with details to be set forth in the respective Addendum. In Cooperative Research Projects where proprietary information by EPRI or third parties needs to be shared with the NRC and protected by the NRC and its employees from unauthorized disclosure, the respective addendum shall also include or reference

¹ NRC published its complete policy statement on meetings open to the public in the *Federal Register* on May 28, 2002 (67 FR 36920-36924). In general, meetings related to Cooperative Research Programs will not be open to public attendance if the subject matter to be discussed includes discussions related to proprietary information or could result in the inappropriate disclosure and dissemination of preliminary, unverified information.

the respective affidavit(s), as applicable, in accordance with the requirements of 10 CFR §2.390, "Public inspections, exemptions, requests for withholding," that provide(s) the basis for withholding from public release EPRI reports that may be shared with the NRC in the process of performing the work associated with the specific Addendum². The affidavit(s) will generally describe the documents or information expected to be exchanged for the specific research program for each addenda.

- d. Management of Cooperative Research Programs. Each Cooperative Research Program will be managed by cognizant program managers and/or a technical review group composed of NRC staff and EPRI employees.
- e. Research Exchanges. NRC and EPRI staff may engage in research exchanges provided it is supported by Senior Management to identify future areas of cooperation, support working groups, or accomplish individual research tasks. An Addendum should be pursued should staff enter into a Research Program as described in 1.3 (b) and (c) requiring organizational commitments. Research exchange on activities involving nuclear safety and security for power plants and fuel cycle facilities are permitted under this provision provided that the guidelines under Article 2 are followed when exchanging information.
- f. Termination of a Cooperative Research Program. Either the NRC or EPRI may elect to terminate a Cooperative Research Program due to unsatisfactory contractor performance, lack of funds, changes in priority, or other reason. To effect a termination, the Senior Management Contact of the terminating party shall provide at least 30 days written notice of the intent to terminate continued participation in the specified Cooperative Research Program to the other party's Senior Management Contact. The terminating party shall provide confirmation of termination and the effective date thereof to the other party. The non-terminating party may continue with the research that is the subject of the Cooperative Research Program and shall have sole control over and use of the results and information obtained from the Cooperative Research Program subsequent to the effective termination date. Results obtained prior to the effective date of termination are governed by Article 2.2.
- g. No Conflict with Federal Rules or Regulations. The NRC's role as an independent agency shall be maintained. Notwithstanding anything to the contrary herein or in any addendum to this Agreement, the cooperation, approval, involvement, or guidance of the NRC staff with regard to the Cooperative Research Programs shall not bind the NRC in any manner especially its rulemaking, licensing, or adjudicatory processes. The occasional use of the term "agree" or mandatory language such as "shall" or "will" in this MOU or any addendum hereto is not intended to constitute a binding obligation and does not create an enforceable right of action on the part of either party. EPRI shall not function as an advisory entity to the NRC. To maintain the NRC's regulatory independence, the parties shall not jointly interpret the results or implications of the data derived from the Cooperative Research Programs. EPRI shall not claim or publish in its studies, releases, reports, or publications any

² This is applicable only to final reports or other intellectual property that EPRI has already developed. Data acquired during the course of the subject collaborative work is considered non-public pre-decisional information and thus will be routinely withheld from release until the final report(s) on this work is/are made publicly available.

statements that indicate the NRC's approval or endorsement of any Cooperative Research Program or any related study, report, or publication without the prior written approval of the NRC's Senior Management Contact.

Article 2 - Guidelines for Cooperative Research


- 2.1 The purpose of each Cooperative Research Program shall be to produce research data and results related to nuclear safety. To maintain independence and to avoid conflicts of interest, or even the appearance of any conflicts of interest, the NRC and EPRI shall not jointly derive any conclusions regarding the data or results obtained from a Cooperative Research Program or the application of such data or results to any regulation or regulatory guidance. The NRC and EPRI may cooperate in the validation and verification of data to ensure it is ready for use by decisionmakers. Any regulatory analysis of the data to determine applicability to and impact on existing or new regulation shall be done independently.
- 2.2 If an electronic reading room is established, the following conditions will be maintained throughout the duration of this MOU.
 - The electronic reading room will be password protected, and passwords will be assigned to staff directly involved in cooperative research on a need-to-know basis.
 - The electronic reading room will be sufficiently secure to prevent staff from printing, saving, or downloading any documents.
 - Conditions of use of the electronic reading room will be displayed on the log-in screen and will require concurrence by each user of the electronic reading room.
- 2.3 All final work products produced by a Cooperative Research Program shall be shared by all participants, and each party shall be free to disseminate them to whomever they choose at no additional cost. Proprietary information supplied by EPRI to support conduct of the research will be marked and protected in accordance with applicable Federal laws, rules, and/or regulations including 10 CFR §2.390. The addenda to this MOU will describe the documents or information to be exchanged for the specific research program involved. In accordance with 10 CFR §2.390 and prior to or contemporaneous with such exchange, EPRI will submit an affidavit covering such material and stating the basis for withholding it from public disclosure if the information has not been described in a previous affidavit.
- 2.4 Publication of non-public data or results from Cooperative Research Programs in journals or conference proceedings by any party or contractor prior to its public release in the final report(s) on this work shall require the written approval of each of the Senior Management Contacts.
- 2.5 The NRC and EPRI will determine, on a project-by-project basis in the respective addenda of pertinent Cooperative Research Programs, if appropriate patent or copyright applications should be filed with regard to the data or results generated by a Cooperative Research Program or whether additional arrangements for intellectual property allocation, use rights, or confidentiality are required due to the nature of the project.

- 2.6 Upon request, each party shall have access, contingent upon meeting any required security clearances, to the contractors' facilities, separately or jointly, and may review the data developed by the other party's contractor that is associated with a specific Cooperative Research Program.
- 2.7 Either the NRC or EPRI may, at its own expense, conduct additional research beyond the scope of the Cooperative Research Program using the same contractor or facility employed with respect to a Cooperative Research Program if it so desires or may employ such other contractors or facilities as it deems appropriate.


Article 3 - Terms of Agreement

- 3.1 The term of this MOU shall commence effective upon signing by both the NRC and EPRI Senior Management Contacts and shall expire on September 30, 2026. The addenda that were active as of September 30, 2021, remain as such until they are terminated in accordance with the requirements of this MOU. A list of addenda that were active as of September 2021 is attached hereto as Table 1.
- 3.2 Either party may terminate this MOU at any time upon 90 days prior written notice of such termination.
- 3.3 This MOU supersedes and replaces the Memorandum of Understanding dated September 30, 2016. Addenda entered into prior to this MOU and referencing previous versions of the Memorandum of Understanding shall continue their respective terms under this umbrella MOU.

The parties hereto acknowledge that this MOU is non-binding and is solely intended to promote cooperative relationships between the parties.


Raymond Furstenau, Director of Nuclear
Regulatory Research
U.S. Nuclear Regulatory Commission

Date: September 28, 2021


Dr. Rita Baranwal, Vice President and
Chief Nuclear Officer
Electric Power Research Institute, Inc.

Date: September 28, 2021

Table 1

Addenda to NRC-EPRI MOU on Cooperative Nuclear Safety and Security Research as of September 2021

Title	NRC Contact	EPRI Contact	Enclosure	Expiration Date
1# Advanced Nuclear Technologies and Data Science	Hossein Esmaili, Chris Hoxie, and Luis Betancourt (RES/DSA)	Craig Stover, Erik Mader, and Rob Austin	Enclosure 3	September 30, 2026
2# Enabling Nuclear Technologies for Plant Modernization and Advanced Reactors	Christopher Cook, Raj Iyengar, and SteveRuffin (RES/DE)	Craig Stover, David Gandy, Erik Mader, and Michael Thow	Enclosure 4	September 30, 2026
3# Fire and External Hazards	Mark Henry Salley, Dogan Seber, and Joseph Kanney (RES/DRA)	Kelli Voelsing	Enclosure 5	September 30, 2026
4# Probabilistic Risk Assessment and Human Reliability Analysis	Mehdi Reisi Fard, Sean Peters (RES/DE)	Kelli Voelsing	Enclosure 6	September 30, 2026
5# Management of Materials Aging and Degradation for Long Term Operations	Christopher Cook, SteveRuffin, Raj Iyengar, Meraj Rahimi, Dogan Seber (RES/DE)	Emma Wong, Jean Smith, Elliot Long, Greg Selby, Andrew Mantey, Greg Frederick, and Hatice Akkurt	Enclosure 7	September 30, 2026
6# Renewal of xLPR and Steam Generator Tube Base Research Program	Matthew Homiack and Patrick Purtscher	Craig Harrington and James Benson	Enclosure 8	September 30, 2026, and December 31, 2023 (ADAMS Accession Numbers for associated Addenda ML20073F692 and ML20227A051)

ADDENDUM
to
MEMORANDUM OF UNDERSTANDING
between
U.S. NUCLEAR REGULATORY COMMISSION
and
ELECTRIC POWER RESEARCH INSTITUTE, INC.
on
COOPERATIVE NUCLEAR SAFETY RESEARCH
Advanced Nuclear Technologies and Data Science

I. Introduction

This Addendum (the Addendum) to the Memorandum of Understanding (MOU) is entered into by and between the U.S. Nuclear Regulatory Commission (NRC) and the Electric Power Research Institute, Inc. (EPRI) effective as of the date of signature of the last of the parties to execute this Addendum (the Effective Date). The NRC and EPRI are parties to that Memorandum of Understanding on Cooperative Nuclear Safety Research (the MOU, found under Enclosure 1). Pursuant to the MOU, the parties agreed to encourage cooperation in nuclear safety research that provides benefits for the NRC, the nuclear power industry (the "Industry"), and the public.

This Addendum describes a cooperative research and development (R&D) program between EPRI and the NRC's Office of Nuclear Regulatory Research (NRC-RES) in the areas of advanced nuclear technologies including advanced fuel technologies, reactors, fuel cycle related facilities, fuel transportation packages, and spent fuel storage casks. This Addendum also includes cooperative research and development for Data Science and Artificial Intelligence. This Addendum replaces the previously signed addenda on accident tolerant fuels (Agencywide Documents Access and Management System [ADAMS] Accession No. ML17248A392) and non-light water reactor technologies (ADAMS Accession No. ML18341A320), and the license Modular Accident Analysis Program (MAAP) user group agreement (ADAMS Accession No. ML17038A516) between NRC-RES and EPRI.

II. Objectives

The overall objective of the ongoing NRC-RES and EPRI Advanced Nuclear Technologies and Data Science R&D programs is the improvement of methods, tools, data, and technical information to support nuclear safety research.

More specific objectives of this cooperative program include the following:

- To ensure the timely exchange of information (e.g., objectives, milestones) on planned and ongoing research activities to foster collaboration and prevent unnecessary duplication of effort.
- To ensure the sharing of technical data needed by the NRC-RES and EPRI R&D programs.
- To ensure the timely sharing of R&D results and tools.
- To build and refine data needed to support risk-informed applications.
- To improve capabilities of current methods and tools.

- To promote the development of advanced methods and tools.
- To collaborate on mutually beneficial experimental projects.

III. Scope

This program includes a wide variety of potential collaborative activities (including information exchange meetings, support for expert panels, jointly sponsored projects, and experiments) aimed at achieving the preceding objectives. The program elements are as follows:

- 1) Programmatic information exchange. Both parties will exchange information concerning the objectives, milestones, and planned approaches for their ongoing R&D tasks.
- 2) Technical information exchange. Both parties will facilitate the exchange of technical information needed to satisfactorily complete each party's R&D tasks.
- 3) Cooperative research projects. In some cases, it may be most efficient for NRC-RES and EPRI to cooperate in performing certain research tasks or projects. These projects will be identified by mutual agreement of both organizations. Areas in which coordinated or cooperative research activities may be undertaken include but are not limited to those summarized below. In each case and especially regarding research identified as potentially subject to joint activities, the decision regarding the extent of collaboration will be based upon mutual agreement.

a) Advanced Fuel Technologies for LWRs

EPRI is coordinating with the nuclear industry on research, technology development, and safety analysis for a number of accident tolerant fuel (ATF) candidate designs as well as gaps associated with higher burnup and increase/ enrichment fuels. Some nuclear utilities are considering full-core utilization of ATF to enable certain margin exchange or probabilistic risk assessment (PRA)-driven changes to their licensing basis. EPRI's goal is to facilitate consistent evaluation of ATF candidates and higher burnup/enrichment fuel as well as to support the nuclear utilities in making decisions about the use of lead test assemblies, batch loading, and related licensing activities.

The NRC is also conducting work in the area of safety analysis for ATF to ensure adequate protection of public health and safety should ATF and higher burnup/enrichment fuels be placed in use. Establishing industrywide approaches for consistent evaluation of ATF candidates and higher burnup/enrichment fuels would greatly support the NRC's effort. The NRC may need to develop a regulatory framework for considering changes to licensing bases. Maintaining up-to-date knowledge of the industry's plans and approach in this area is critical to the NRC's effort.

In this spirit, the NRC and EPRI intend to coordinate in the following manner:

- i) Research on deterministic ATF and higher burnup/enrichment fuel thermal-mechanical design criteria: The NRC staff intends to participate in EPRI-sponsored expert elicitations on ATF R&D needs (and vice versa) to define figures of merit or performance indicators used to assess thermal-mechanical aspects of ATF and higher burnup/enrichment fuel performance. The NRC and EPRI staffs intend to discuss data and model gaps in the area of thermal-mechanical

performance codes required to accurately model ATF and higher burnup/enrichment fuel performance.

- ii) Research to characterize the safety and risk significant characteristics of ATF and higher burnup enrichment fuel as part of an integrated nuclear reactor system: The NRC staff intends to participate in EPRI-sponsored expert elicitations on key figures of merit or performance indicators for integrated plant performance with various ATF concepts and higher burnup/enrichment fuel (and vice versa). The NRC staff intends to participate in EPRI-sponsored discussion on key accident sequences for the assessment of integrated plan performance. The NRC and EPRI intend to share information about modeling approaches for ATF and higher burnup/enrichment designs, possibly including code-comparison exercises.
- iii) The NRC staff intends to participate in periodic workshops coordinated by EPRI on R&D progress of ATF concepts and higher burnup/enrichment fuels.
- iv) The NRC and EPRI staffs intend to discuss the NRC's ongoing efforts to build the technical and regulatory infrastructure necessary to review and license ATF designs.
- v) The NRC and EPRI staffs intend to discuss participation in and co-funding through U.S. consortia in multi-lateral research projects investigating ATF concepts and higher burnup/enrichment fuels including those managed by the OECD-Nuclear Energy Agency. This cooperation is in addition to joint/bilateral projects generally stated in the description for above item 3).

b) Advanced non-light water reactor (non-LWR) technologies

EPRI is coordinating with the nuclear industry on research, technology development, and safety analysis for a number of advanced reactor designs. EPRI's goal is to facilitate consistent evaluation of non-LWR designs and to support the nuclear utilities in making decisions about the related licensing activities.

The NRC is preparing to review and regulate a new generation of non-LWRs by conducting work related to six individual strategies:

1. Acquire/develop sufficient knowledge, technical skills, and capacity to perform non-LWR regulatory activities.
2. Acquire/develop sufficient computer codes and tools to perform non-LWR regulatory reviews.
3. Establish a more flexible, risk-informed, performance-based, non-LWR regulatory review process within the bounds of existing regulations including the use of conceptual design reviews and staged-review processes. This flexibility will accommodate potential applicants having a range of financial, technical, and regulatory maturity and a range of application readiness.
4. Facilitate industry codes and standards needed to support the non-LWR life cycle (including fuels and materials).
5. Identify and resolve technology-inclusive (not specific to a particular non-LWR design or category) policy issues that impact regulatory reviews, siting, permitting, and/or licensing of non-LWR nuclear power plants (NPPs).

6. Develop and implement a structured, integrated strategy to communicate with internal and external stakeholders having interests in non-LWR technologies.

In this spirit, the NRC and EPRI will coordinate in the following manner:

- i) The NRC staff and EPRI staff will discuss data needs for (1) updating analytical codes and models, qualifying materials; (2) demonstrating performance of structures, systems, and components (SSCs); or (3) verifying operational characteristics of non-LWR technologies. NRC staff and EPRI staff may also discuss approaches to obtaining needed data.
- ii) The NRC staff and EPRI staff will participate in workshops on research and development progress of non-LWR designs and technologies.
- iii) The NRC staff and EPRI staff will share information about modeling approaches for non-LWR designs, possibly including code comparison exercises.
- iv) The NRC staff and EPRI staff will cooperate on research activities related to advanced sensors and instrumentation and controls (I&C) systems needed for non-LWR designs.
- v) The NRC staff and EPRI staff will discuss the methods, modeling assumptions, and data important for developing probabilistic risk assessment models to support risk-informed decisionmaking.
- vi) The NRC staff and EPRI staff will discuss the approaches that would support determining appropriate risk metrics and end-state conditions for assessing the risk significance of SSCs important to the safe operation of non-LWR designs.
- vii) The NRC staff and EPRI staff will discuss the approaches for the evaluation of human and organizational factors in the area of advanced concepts for conduct of operations (advanced control technologies, new operational concepts, and different accident types).

c) Data Science and Artificial Intelligence (AI)

Advances in computing technologies have led to the expanded use of data science and AI across multiple disciplines, in both the public and private sectors. These technologies provide new opportunities for organizations to enhance safety and security, improve processes, leverage historical and current data, identify research needs, and even explore autonomous control and operation. As a result, significant industry interest exists in deploying these technologies to meet our future national energy needs. Both the nuclear industry and NRC stand to gain from potential enhancements, process improvements, and efficiencies. To improve operational efficiency, the nuclear industry has already begun to investigate, develop, and assess how such technology can be used.

As more AI tools become widely adopted, the NRC is looking into how these tools may be applied and be ready to adequately evaluate the use of AI technologies in NRC-regulated activities to ensure public health, safety, security, and environmental protection. Thus, the NRC is actively engaged in its internal transformation initiative to better train and prepare staff and use data science and AI methods to regulate data science and AI applications and communicate with external stakeholders.

For the purposes of this MOU, AI is an umbrella term to encompass various computer science subspecialties including, but not limited to, machine learning, natural language processing (NLP), and deep learning. In this spirit, the NRC and EPRI intend

to coordinate on relevant nuclear-related data science and AI R&D. Example areas of cooperation include but are not limited to:

- i) Collaboration on explainable and trustworthy AI, including standards adoption and evaluation of the robustness of AI applied in areas such as digital twins, predictive maintenance, probabilistic risk assessment (PRA), operating experience, control automation, safety and security system simulation and code usage, and non-destructive evaluation (NDE).
 - ii) Evaluation of potential use cases of AI in the nuclear industry.
 - iii) Cooperation on consistent data sets for AI and machine learning model development and coordination on a consistent discipline-specific data vocabulary between the NRC and industry to assist in NLP and confirmatory analyses, along with access to a repository of shared datasets and tools.
 - iv) Collaboration on data science techniques, data visualizations or decision support tools that enhance communication, reduce regulatory uncertainty, accelerate decisionmaking, and provide valuable insights to regulatory and business evidence-based predictions.
 - v) Collaboration on data science and AI training and staff development.
- 4) Other Parties. Recommendations concerning the participation of other parties (whether domestic or international) will be jointly developed and reviewed with NRC/RES and EPRI management. All technical interactions will be managed through a designated point of contact for each party. All EPRI data and materials subject to commercial or other use restrictions will be submitted to the NRC under a general affidavit addressing all documents, data, and materials to be shared with the NRC pursuant to this Addendum and requesting that such documents, data, and materials be withheld from disclosure to the public pursuant to Title 10, Section 2.390, of the *Code of Federal Regulations* (10 CFR 2.390), as provided in the MOU.
- 5) Royalty-Free Limited License Agreement for Proprietary Software. EPRI hereby grants to the NRC a royalty-free, nonexclusive, revocable, nontransferable license limited to the territory of the United States and only for the use of Authorized Users (as defined below) to use the Software and the EPRI MAAP reports only for the purpose of (i) comparing results from the Software and MELCOR and (ii) checking regulatory submittals by nuclear power utilities to the NRC. Access to and use of the Software and Reports will be restricted to those employees of the NRC listed on Attachment 1 hereto (the "Authorized Users"). The Authorized Users may be modified from time to time by the NRC by providing written notice of such modification to EPRI.
- 6) Seminars/Workshops. Subject to continuing stakeholder needs and interest, NRC-RES and EPRI will collaborate to conduct seminars and workshops relating to the technical areas outlined in this addendum.
- 7) Future Collaboration Areas. Additional advanced nuclear technologies and data science activities may be identified and pursued jointly as appropriate. EPRI and RES will continue to jointly participate, when appropriate, in the identification of additional areas of mutual interest for joint collaborative activities that will be added to this Addendum.

IV. Period of Performance

The initial period of performance will be from the Effective Date through September 30, 2026, to be extended or revised in writing if mutually agreeable to EPRI and the NRC.

V. Project Direction and Coordination

All technical interactions will be managed through designated points of contact for each party, for each technical area (the "Project Contacts"). Technical meetings to coordinate this effort and to discuss project progress will be arranged through the respective Project Contacts. The Project Contacts are:

<p>NRC-RES: Office of Nuclear Regulatory Research U.S. Nuclear Regulatory Commission 11545 Rockville Pike, MS TWFN 09-A60M Rockville, MD 20852</p> <p>Advanced Nuclear Technologies: Hossein Esmaili Chief, Fuel and Source Term Code Development Branch 301-415-2155 Hossein.Esmaili@nrc.gov</p> <p>Chris L. Hoxie Chief, Code and Reactor Analysis Branch 301-415-2016 Chris.Hoxie@nrc.gov</p> <p>Data Science and Artificial Intelligence (and MAAP): Luis Betancourt Chief, Accident Analysis Branch 301-415-6146 luis.betancourt@nrc.gov</p>	<p>EPRI: 1300 West WT Harris Boulevard Charlotte, NC 28262</p> <p>Advanced Nuclear Technologies: Craig Stover Program Manager (704) 595-2990 cstover@epri.com</p> <p>Advanced Fuel Technologies: Erik Mader Senior Program Manager (208) 340-2194 emader@epri.com</p> <p>Data Science and Artificial Intelligence: Rob Austin Sr. Program Manager (704) 595-2529 raustin@epri.com</p>
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VI. Cost and Schedule

EPRI and the NRC are responsible for their respective costs in implementing this Addendum. This Addendum does not create any binding obligation or enforceable right of action of any kind on the part of either party. This Agreement does not obligate any funds and is subject to the availability of appropriated funds.

ATTACHMENT 1

Modular Accident Analysis Program (MAAP) Authorized Users

NRC staff members who are authorized to use MAAP:

- Shawn Campbell
- Yung Hsien James Chang
- James Corson
- Anne-Marie Grady
- Salman Haq
- Alfred (Trey) Hathaway
- Michael Salay
- Jason Schaperow
- Nicholas G. Trikouros

ADDENDUM
to
MEMORANDUM OF UNDERSTANDING
between
U.S. NUCLEAR REGULATORY COMMISSION
and
ELECTRIC POWER RESEARCH INSTITUTE, INC.
on
COOPERATIVE NUCLEAR SAFETY RESEARCH

Enabling Nuclear Technologies for Plant Modernization and Advanced Reactors

I. Introduction

This Addendum to Memorandum of Understanding (the Addendum) is entered into by and between the U.S. Nuclear Regulatory Commission (NRC) and the Electric Power Research Institute, Inc. (EPRI) effective as of the date of signature of the last of the parties to execute this Addendum (the Effective Date). NRC and EPRI are parties to that Memorandum of Understanding on Cooperative Nuclear Safety Research (the MOU, found under Enclosure 1). Pursuant to the MOU, the parties agreed to encourage cooperation in nuclear safety research, which provides benefits for the NRC, the nuclear power industry (the "Industry"), and the public.

This Addendum describes information exchange and potential cooperative research and development (R&D) program in advanced nuclear technologies supporting plant modernization and advanced reactors between EPRI and the NRC's Office of Nuclear Regulatory Research (NRC-RES). This addendum replaces the previously signed addenda on Advanced Manufacturing Technologies (AMT) (ML19101A205) (Item 3. A.) and Digital Instrumentation and Control and Human Factors (ML16223A502) (Item 3. g.). It also includes and expands the cooperative research to cover areas such as: items 3) b. Materials and components for high temperature applications, c. Advanced sensors and tools for reliability of components and equipment, d. Risk-informed pre-service and in-service inspection techniques for advanced nuclear plant designs, e. Fuel cycle, transportation and storage of radioactive materials and spent nuclear fuel, and f. Digital twins applications.

II. Objectives

The overall objective of the NRC-RES and EPRI advanced nuclear technologies R&D programs is the improvement of methods, tools, data, and technical information to support nuclear safety research.

More specific objectives of this cooperative program include the following:

1. To ensure the timely exchange of information (e.g., objectives, milestones) on planned and ongoing research activities to foster collaboration and prevent unnecessary duplication of effort.
2. To ensure the sharing of technical data needed by the NRC-RES and EPRI R&D programs.
3. To ensure the timely sharing of R&D results and tools.
4. To build and refine data needed to support risk-informed applications.
5. To improve capabilities of current methods and tools.
6. To promote the development of advanced methods and tools.
7. To collaborate on mutually beneficial experimental projects.

III. Scope

This program includes a wide variety of potential collaborative activities (including information exchange meetings, support for expert panels, jointly sponsored projects and experiments) aimed at achieving the preceding objectives.

The program elements are as follows.

- 1) Programmatic information exchange. Both parties will exchange information concerning the objectives, milestones, and planned approaches for their ongoing R&D tasks.
- 2) Technical information exchange. Both parties will facilitate the exchange of technical information needed to satisfactorily complete each party's R&D tasks.
- 3) Cooperative research projects. In some cases, it may be most efficient for NRC-RES and EPRI to cooperate in performing certain research tasks or projects. These projects will be identified by mutual agreement of both organizations. Areas in which coordinated or cooperative research activities may be undertaken include but are not limited to those summarized below. In each case, and especially with regard to research identified as potentially subject to joint activities, the decision regarding the extent of collaboration will be based upon mutual agreement.
 - a) Advanced Manufacturing Technologies
 - i) EPRI and NRC-RES will continue to participate in joint activities that promote the timely exchange of information (e.g., objectives, milestones, technical data, and results) on planned and ongoing advanced manufacturing research activities.
 - ii) Example areas of cooperation include but are not limited to assessment of advanced manufacturing technologies that can be used for the structural and pressure-retaining components for traditional light-water reactors, small modular reactors, and advanced reactors; evaluation of monitoring and non-destructive examination methods that can be used to inspect component made using AMTs; assessment of the performance and degradation/aging effects of AMT components relative to those produced by traditional methods; and codes and standards activities.
 - b) Materials and components for high temperature applications
 - i) EPRI and NRC-RES will continue to participate in joint activities that promote the timely exchange of information (e.g., objectives, milestones, technical data, and results) on planned and ongoing activities related to materials and components for high temperature applications.
 - ii) Example areas of cooperation include but are not limited to high-temperature materials and component integrity for advanced non-light water reactor applications; molten salt compatibility and chemistry; graphite performance and assessment of ASME Code related to materials qualification; use of advanced technologies for reduction of uncertainties and risk.
 - c) Advanced sensors and tools for reliability of components and equipment
 - i) Example areas of cooperation include but are not limited to evaluation of sensor technologies for online monitoring/condition monitoring; the state of art in prognostic health management (PHM) technology (to include advanced sensors, online monitoring, and algorithms for diagnostics and prognostics); the feasibility of applying the technology to assess the condition of active and passive components in advanced reactors.

- d) Risk-informed pre-service and in-service inspection techniques for advanced nuclear plant designs
 - i) Example areas of cooperation include but are not limited to assessing the use of risk-informed technology for defining PSI and ISI requirements for advanced nuclear plant designs; sharing approaches for determining appropriate reliability targets for structures, systems, and components (SSCs) to support implementation of ASME Section XI, Division 2 Reliability Integrity Management program; evaluating methods and monitoring and NDE techniques that can be used to demonstrate performance of SSCs for advanced non-light water reactors and the safe use of nuclear materials for fuel-cycle and spent-fuel storage facilities.

- e) Fuel cycle, transportation and storage of radioactive materials and spent nuclear fuel
 - i) Example areas of cooperation include but are not limited to enrichment and transportation of advanced fuel technologies, aging processes and long term operation of independent spent fuel storage installations, consequence and/or probabilistic assessments for transportation and storage of spent fuel, repair and mitigation methods for dry storage systems, sensor technologies for continuous or periodic monitoring of dry storage systems.

- f) Digital twins applications
 - i) EPRI and NRC-RES will participate in joint activities that promote the timely exchange of information (e.g., objectives, milestones, technical data, and results) aimed at identifying and evaluating the technical issues and gaps that would impact regulatory outcomes related to the applications of digital twins and associated enabling technologies for nuclear reactors and
 - ii) Example areas of cooperative efforts will include but are not limited to technical elements related to engineering aspects of digital twins of reactor systems involving the design, analysis, fabrication, maintenance, operation; and associated analytical methodologies for evaluation of the SSCs' performance and dynamics of mechanical systems using multi-physics, artificial intelligence, machine learning, big data, and data analytics.

- g) Digital Instrumentation & Control – Safety and Security
 - i) EPRI and NRC-RES will continue to participate in joint activities that promote the timely exchange of information (e.g., objectives, milestones, technical data, and results) on planned and ongoing activities aimed at improving the implementation of digital I&C in commercial nuclear facilities.
 - ii) Example areas of cooperative efforts will include but are not be limited to technical elements related to fundamental design principles and modernization of the NRC's regulatory infrastructure related to I&C; digital I&C system operational experience, inventory, characterization, and analysis of digital I&C systems in nuclear and other industries using safety-related/important-to-safety equipment; security of digital I&C systems, cyber security assessment methods, lessons learned from operating experience, and impact of security vulnerabilities on safety-related/important-to-safety systems.

- 4) Other Parties. Recommendations concerning the participation of other parties (whether domestic or international) will be jointly developed and reviewed with NRC/RES and EPRI management. All technical interactions will be managed through a designated point of contact for each party. All EPRI data and materials subject to commercial or other use restrictions will be submitted to the NRC under a general affidavit addressing all documents, data, and materials to be shared with the NRC pursuant to this Addendum and requesting that such documents,

data, and materials be withheld from disclosure to the public pursuant to Title 10, Section 2.390, of the *Code of Federal Regulations* (10 C.F.R. 2.390), as provided in the MOU.

- 5) Seminars/Workshops. Subject to continuing stakeholder needs and interest, NRC-RES and EPRI will collaborate to conduct seminars and workshops relating to the technical areas outlined in this addendum.
- 6) Future Collaboration Areas. Additional research activities related to advanced nuclear technologies may be identified and pursued jointly as appropriate. EPRI and RES will continue to jointly participate, when appropriate, in the identification of additional areas of mutual interest for joint collaborative activities that will be added to this Addendum.

IV. Period of Performance

The initial period of performance will be from the Effective Date through September 30, 2026, to be extended or revised in writing if mutually agreeable to EPRI and NRC.

V. Project Direction and Coordination

All technical interactions will be managed through designated points of contact for each party and for each technical area (the "Project Contacts"). Technical meetings to coordinate this effort and to discuss project progress will be arranged through the respective Project Contacts. The Project Contacts are:

NRC:	EPRI:
Christopher Cook, Chief Instrumentation and Controls and Electrical Engineering Branch Christopher.Cook@nrc.gov	Advanced Nuclear Technologies: Craig Stover Program Manager cstover@epri.com
Raj Iyengar, Chief Reactor Engineering Branch Raj.Iyengar@nrc.gov	Advanced Manufacturing: David Gandy davgandy@epri.com
Steve Ruffin, Chief Materials Engineering Branch Steve.Ruffin@nrc.gov	Fuel Cycle: Erik Mader Sr. Program Manager emader@epri.com
Office of Nuclear Regulatory Research · U.S. Nuclear Regulatory Commission 11545 Rockville Pike, MS TWFN 09-A60M Rockville, MD 20852	Digital I&C: Michael Thow Program Manager mthow@epri.com

VI. Cost and Schedule

EPRI and the NRC are responsible for their respective costs in implementing this Addendum. This Addendum does not create any binding obligation or enforceable right of action of any kind on the part of either party. This Agreement does not obligate any funds and is subject to the availability of appropriated funds.


VII. Disputes

If a dispute arises out of or relating to this Addendum or any breach thereof, the parties will first attempt to settle the dispute through direct negotiation between the Project Contacts. If such a dispute cannot be settled by the Project Contacts, the dispute shall be submitted to the Senior Management Contacts (as defined in the MOU) for resolution.

AGREEMENT

 9/28/2021

Raymond Furstenau Date
Director of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission

 9/28/2021

Dr. Rita Baranwal Date
Vice President and Chief Nuclear Officer
Electric Power Research Institute

ADDENDUM
to
MEMORANDUM OF UNDERSTANDING
between
U.S. NUCLEAR REGULATORY COMMISSION
and
ELECTRIC POWER RESEARCH INSTITUTE, INC.
on
COOPERATIVE NUCLEAR SAFETY RESEARCH

Fire and External Hazards

I. Introduction

This Addendum to Memorandum of Understanding (the Addendum) is entered into by and between the U.S. Nuclear Regulatory Commission (NRC) and the Electric Power Research Institute, Inc. (EPRI) effective as of the date of signature of the last of the parties to execute this Addendum (the Effective Date). The NRC and EPRI are parties to that Memorandum of Understanding on Cooperative Nuclear Safety Research (the MOU, found under Enclosure 1). Pursuant to the MOU, the parties agreed to encourage cooperation in nuclear safety research that provides benefits for the NRC, the nuclear power industry (the "Industry"), and the public.

This Addendum describes a cooperative research and development program in the area of nuclear power plant (NPP) hazard analysis research and development (R&D) between EPRI and the NRC's Office of Nuclear Regulatory Research (NRC-RES). This addendum replaces the previously signed addenda on Seismic Risk ([ML16223A499](#)), Fire Risk ([ML16223A503](#)), and External Flood Hazards ([ML15321A365](#)) between NRC-RES and EPRI.

II. Objectives

The overall objective of the ongoing NRC-RES and EPRI hazard analysis R&D programs is the improvement of methods, tools, data, and technical information to support nuclear safety research.

More specific objectives of this cooperative program include the following:

1. To ensure the timely exchange of information (e.g., objectives, milestones) on planned and ongoing research activities to foster collaboration and prevent unnecessary duplication of effort.
2. To ensure the sharing of technical data needed by the NRC-RES and EPRI R&D programs.
3. To ensure the timely sharing of R&D data and tools.
4. To build and refine data needed to support risk-informed applications.
5. Assess the capabilities of current PRA methods and tools and advanced capabilities where needed.
6. Develop PRA methods, tools, and/or data needed to support risk-informed applications.
7. To collaborate on mutually beneficial experimental projects.

III. Scope

This program includes a wide variety of potential collaborative activities (including information exchange meetings, support for expert panels, and jointly sponsored projects and experiments) aimed at achieving the preceding objectives.

The program elements are as follows:

- 1) Programmatic information exchange. Both parties will exchange information concerning the objectives, milestones, and planned approaches for their ongoing R&D tasks.
- 2) Technical information exchange. Both parties will facilitate the exchange of technical information needed to satisfactorily complete each party's R&D tasks.
- 3) Cooperative research projects. In some cases, it may be most efficient for NRC-RES and EPRI to cooperate in performing certain research tasks or projects. These projects will be identified by mutual agreement of both organizations. Areas in which coordinated or cooperative research activities may be undertaken include but are not limited to those summarized below. In each case, and especially with regard to research identified as potentially subject to joint activities, the decision regarding the extent of collaboration will be based upon mutual agreement.
 - a) Fire Hazards
 - i) Fire Probabilistic Risk Assessment (FPRA): EPRI and NRC-RES will continue to participate in joint activities to provide improved guidance on conducting FPRAs using the methods, tools, and data developed under the NRC Fire Risk Research Program, the Fire Research Focus Area (RFA) within EPRI's Risk and Safety Management (RSM) Research Portfolio, joint research conducted as part of other projects under this Addendum, as well as other pertinent research programs within the two organizations. Collaboration includes projects to improve the realism of FPRA methods and documentation of lessons learned and insights from the application of FPRA methodologies including examination and updating of PRA methods based on applicable operational data.
 - ii) Fire Modeling: The NRC-RES and EPRI will continue to participate in a number of joint activities intended to develop guidance for and development and application of fire PRAs and risk applications that consider insights from fire PRAs.
 - iii) Testing: Technical collaboration on testing will be pursued for projects that are producing data to improve the knowledge for the application of FPRA where collaboration will enhance the extent to which results are useful to elements of FPRA, including fire modeling.
 - iv) Data Collection Sharing: Numerous databases are available to EPRI that would improve the understanding and quantification of FPRA. NRC-RES and EPRI will collaborate on data collection and analysis projects as appropriate.
 - b) Seismic, External Flooding, and Other Hazards
 - i) Seismic Hazard, Fragility, and System Modeling
 - (1) Research efforts in seismic hazard, fragility, and system modeling offer many opportunities for collaborative research that could be mutually beneficial to the NRC and EPRI while limiting unnecessary duplication of efforts. Potential examples include ground motion and site response enhancements, kappa modeling in hazard calculations, and fragility methods for items sensitive to hazard changes.
 - (2) Given more recent requirements to evaluate external hazard changes more actively on the operating fleet, an important opportunity exists to develop mutually agreed upon simplified, risk-informed methods to evaluate changes in hazards, fragilities, and systems models. Research in these areas will be vital to understanding the impacts of ongoing scientific changes while maintaining regulatory stability. Potential examples include simplified methods for estimating updated mean seismic hazards, updates to plant-level fragilities, and simplified quantification methods to estimate changes in plant risks due to hazard and fragility changes.

- ii) External Flooding Hazards
 - (1) Example areas of cooperation include but are not limited to: Characterization and probabilistic assessment of external flood hazards, incorporation of external flood effects into PRAs, including identification of potential impacts of flooding on plant systems, structures and components and HRA (e.g., manual actions for flood protection and mitigation). NRC-RES and EPRI may also cooperate in sharing insights from pilot testing of technical approaches and methods in the areas outlined above.
 - (2) Throughout any collaboration effort, a point of emphasis would be to identify the relevant data sources, assess the quality of the data available, as well as to characterize and quantify uncertainties.
 - iii) Other Aspects of External Hazards
 - (1) Example areas of cooperation include but are not limited to characterization and probabilistic assessment of new or changing external hazards including but not limited to high winds, other extreme weather events that can impact NPPs, coincident hazards, and technical considerations associated with the impact of these types of hazards.
- 4) Other Parties. Recommendations concerning the participation of other parties (whether domestic or international) will be jointly developed and reviewed with NRC/RES and EPRI management. All technical interactions will be managed through a designated point of contact for each party. All EPRI data and materials subject to commercial or other use restrictions will be submitted to the NRC under a general affidavit addressing all documents, data, and materials to be shared with the NRC pursuant to this Addendum and requesting that such documents, data, and materials be withheld from disclosure to the public pursuant to Title 10, Section 2.390, of the *Code of Federal Regulations* (10 C.F.R. 2.390), as provided in the MOU.
 - 5) Seminars/Workshops/Training. Subject to continuing stakeholder needs and interest, NRC-RES and EPRI will collaborate to conduct seminars, workshops, and training relating to the technical areas outlined in this addendum.
 - 6) Future Collaboration Areas. Additional hazard analysis activities may be identified and pursued jointly as appropriate. EPRI and RES will continue to jointly participate, when appropriate, in the identification of additional areas of mutual interest for joint collaborative activities that will be added to this Addendum.

IV. Period of Performance

The initial period of performance will be from the Effective Date through September 30, 2026, to be extended or revised in writing if mutually agreeable to EPRI and the NRC.

V. Project Direction and Coordination

All technical interactions will be managed through designated points of contact for each party for each technical area (the "Project Contacts"). Technical meetings to coordinate this effort and to discuss project progress will be arranged through the respective Project Contacts. The Project Contacts are:

<p>NRC:</p> <p>Fire Hazards: Mark Henry Salley Chief, Fire and External Hazards Analysis Branch Office of Nuclear Regulatory Research · U.S. Nuclear Regulatory Commission 11545 Rockville Pike, MS TWFN 09-A60M Rockville, MD 20852 301-415-2474 MarkHenry.Salley@nrc.gov</p> <p>Seismic Hazards: Dogan Seber Chief, Seismic, Geotechnical and Structural Engineering Branch 301-415-0212 Dogan.Seber@nrc.gov</p> <p>External Flood Hazards: Joseph Kanney Hydrologist 301-415-1920 Joseph.Kanney@nrc.gov</p>	<p>EPRI:</p> <p>Kelli Voelsing Senior Program Manager, Risk and Safety Management EPRI 1300 West WT Harris Blvd Charlotte, NC 28262 kvoelsing@epri.com</p>
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VI. Cost and Schedule

EPRI and the NRC are responsible for their respective costs in implementing this Addendum. This Addendum does not create any binding obligation or enforceable right of action of any kind on the part of either party. This Agreement does not obligate any funds and is subject to the availability of appropriated funds.


VII. Disputes

If a dispute arises out of or relating to this Addendum or any breach thereof, the parties will first attempt to settle the dispute through direct negotiation between the Project Contacts. If such a dispute cannot be settled by the Project Contacts, the dispute shall be submitted to the Senior Management Contacts (as defined in the MOU) for resolution.

AGREEMENT

 9/28/2021

Raymond Furstenu Date
Director of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission

 9/28/2021

Dr. Rita Baranwal Date
Vice President and Chief Nuclear Officer
Electric Power Research Institute

ADDENDUM
to
MEMORANDUM OF UNDERSTANDING
between
U.S. NUCLEAR REGULATORY COMMISSION
and
ELECTRIC POWER RESEARCH INSTITUTE, INC.
on
COOPERATIVE NUCLEAR SAFETY RESEARCH

Probabilistic Risk Assessment and Human Reliability Analysis

I. Introduction

This Addendum to Memorandum of Understanding (the Addendum) is entered into by and between the U.S. Nuclear Regulatory Commission (NRC) and the Electric Power Research Institute, Inc. (EPRI) effective as of the date of signature of the last of the parties to execute this Addendum (the Effective Date). The NRC and EPRI are parties to that Memorandum of Understanding on Cooperative Nuclear Safety Research (the MOU, found under Enclosure 1). Pursuant to the MOU, the parties agreed to encourage cooperation in nuclear safety research that provides benefits for the NRC, the nuclear power industry (the "Industry"), and the public.

This Addendum describes a cooperative research and development program in the area of nuclear power plant (NPP) risk analysis research and development (R&D) between EPRI and the NRC's Office of Nuclear Regulatory Research (NRC-RES). This Addendum replaces the previously signed addenda on Probabilistic Risk Assessment (PRA) ([ML16223A507](#)). It also includes and expands the cooperative research and development program for Human Reliability Analysis described in portions of the previously signed Digital Instrumentation and Control and Human Factors ([ML16223A502](#)) addendum.

II. Objectives

The overall objective of the ongoing NRC-RES and EPRI risk analysis R&D programs is the improvement of methods, tools, data, and technical information to support nuclear safety research.

More specific objectives of this cooperative program include the following:

1. To ensure the timely exchange of information (e.g., objectives, milestones) on planned and ongoing research activities to foster collaboration and prevent unnecessary duplication of effort.
2. To ensure the sharing of technical data needed by the NRC-RES and EPRI R&D programs.
3. To ensure the timely sharing of R&D data and tools.
4. To build and refine data needed to support risk-informed applications.
5. Assess the capabilities of current PRA methods and tools and advance capabilities where needed.
6. Develop PRA methods, tools, and/or data needed to support risk-informed applications.
7. To collaborate on mutually beneficial experimental projects.

III. Scope

This program includes a wide variety of potential collaborative activities (including information exchange meetings, support for expert panels, and jointly sponsored projects and experiments) aimed at achieving the preceding objectives.

The program elements are as follows:

- 1) Programmatic information exchange. Both parties will exchange information concerning the objectives, milestones, and planned approaches for their ongoing R&D tasks.
- 2) Technical information exchange. Both parties will facilitate the exchange of technical information needed to satisfactorily complete each party's R&D tasks.
- 3) Cooperative research projects. In some cases, it may be most efficient for NRC-RES and EPRI to cooperate in performing certain research tasks or projects. These projects will be identified by mutual agreement of both organizations. Areas in which coordinated or cooperative research activities may be undertaken include but are not limited to those summarized below. In each case, and especially with regard to research identified as potentially subject to joint activities, the decision regarding the extent of collaboration will be based upon mutual agreement.
 - a) Probabilistic Risk Assessment (PRA)
 - i) Example areas of cooperation include but are not limited to PRA modeling methods and supporting analyses for various hazards and modes of operation, operating experience data and analysis of data for reliability estimates, initiating event data and guideline development for different hazards and modes, treatment of uncertainties, aggregation of risk metrics, approaches and tools for sharing risk insights, and human reliability analysis.
 - ii) Both parties will participate in a cooperative R&D program to develop practicable and technically sound consensus guidance for PRA methodology applications for the issues identified in Section II (above). In addition, EPRI and the NRC will solicit participation of other nuclear industry groups in this effort.
 - b) Human Reliability Analysis
 - i) Example areas of cooperation include but are not limited to time responses for manual actions, adequacy of controls and displays, computerized procedures, soft controls, effects of degraded I&C on human performance, and concepts of operation.
- 4) Other Parties. Recommendations concerning the participation of other parties (whether domestic or international) will be jointly developed and reviewed with NRC/RES and EPRI management. All technical interactions will be managed through a designated point of contact for each party. All EPRI data and materials subject to commercial or other use restrictions will be submitted to the NRC under a general affidavit addressing all documents, data, and materials to be shared with the NRC pursuant to this Addendum and requesting that such documents, data, and materials be withheld from disclosure to the public pursuant to Title 10, Section 2.390, of the *Code of Federal Regulations* (10 C.F.R. 2.390), as provided in the MOU.
- 5) Seminars/Workshops. Subject to continuing stakeholder needs and interest, NRC-RES and EPRI will collaborate to conduct seminars and workshops relating to the technical areas outlined in this addendum.
- 6) Future Collaboration Areas. Additional risk analysis activities may be identified and pursued jointly as appropriate. EPRI and RES will continue to jointly participate, when appropriate, in the identification of additional areas of mutual interest for joint collaborative activities that will be added to this Addendum.

IV. Period of Performance

The initial period of performance will be from the Effective Date through September 30, 2026, to be extended or revised in writing if mutually agreeable to EPRI and the NRC.

ADDENDUM
to
MEMORANDUM OF UNDERSTANDING
between
U.S. NUCLEAR REGULATORY COMMISSION
and
ELECTRIC POWER RESEARCH INSTITUTE, INC.
on
COOPERATIVE NUCLEAR SAFETY RESEARCH

Management of Materials Aging and Degradation for Long Term Operations

I. Introduction

This Addendum to the Memorandum of Understanding (the Addendum) is entered into by and between the U.S. Nuclear Regulatory Commission (NRC) and the Electric Power Research Institute, Inc. (EPRI) effective as of the date of signature of the last of the parties to execute this Addendum (the Effective Date). The NRC and EPRI are parties to that Memorandum of Understanding on Cooperative Nuclear Safety Research (the MOU, found under Enclosure 1). Pursuant to the MOU, the parties agreed to encourage cooperation in nuclear safety research that provides benefits for the NRC, the nuclear power industry (the "Industry"), and the public.

This Addendum to the MOU is authorized pursuant to Section 31 of the Atomic Energy Act (AEA) and/or Section 205 of the Energy Reorganization Act (ERA). The roles, responsibilities, terms, and conditions of this Addendum to the MOU should not be interpreted in a manner inconsistent with and shall not supersede applicable Federal laws and regulations.

This Addendum describes information exchange and a potential cooperative aging management research and development (R&D) program between EPRI and the NRC's Office of Nuclear Regulatory Research (NRC-RES) in the area of nuclear power plant (NPP) long-term operations (LTO). This Addendum replaces the previously signed Addendum on Long-Term Operations Beyond 60 Years (ML16223A504). It also includes and expands the cooperative research related to aging management described in several other previously signed addenda to include such areas as research on primary water stress corrosion cracking (PWSCC); neutron absorber materials; non-destructive examination (NDE) and condition monitoring (including metals, concrete, and cables); repair and replacement of components; and joining and welding. This Addendum supersedes the following previously signed addenda:

- Long Term Operations Beyond 60 Years (ML16223A504).
- Primary Water Stress Corrosion Cracking - Crack Initiation Testing (ML16223A505).
- Primary Water Stress Corrosion Cracking Expert Panel Activities (ML16223A506).
- Evaluation of Neutron Absorber Materials for Wet and Dry Storage – Rev. 1 (ML18256A008).
- Nondestructive Examination (ML16138A554).
- Aging, Qualification, and Condition Monitoring of Electrical Cables (ML16223A501).

II. Objectives

The overall objective of the NRC-RES and EPRI aging management R&D programs is the improvement of methods, tools, data, and technical information useful to support nuclear safety research.

More specific objectives of this cooperative program include the following:

1. To ensure the timely exchange of information (e.g., objectives, milestones) on planned and ongoing research activities to foster collaboration and prevent unnecessary duplication of effort.
2. To ensure the sharing of technical data needed by the NRC-RES and EPRI R&D programs,
3. To ensure the timely sharing of R&D results and tools,
4. To build and refine data needed to support risk-informed applications,
5. To improve capabilities of current methods and tools,
6. To promote the development of advanced methods and tools, and
7. To collaborate on mutually beneficial experimental projects.

III. Scope

This program includes a wide variety of potential collaborative activities (including information exchange meetings, support for expert panels, and jointly sponsored projects and experiments) aimed at achieving the preceding objectives.

The program elements are as follows:

- 1) Programmatic information exchange. Both parties will exchange information concerning the objectives, milestones, and planned approaches for their ongoing R&D tasks that are applicable to the specific scopes of research collaboration defined herein. This may include the timely exchange of information on technical approaches, test plans, unprocessed data, interim results, and draft and final reports.
- 2) Technical information exchange. Both parties will facilitate the exchange of technical information needed to satisfactorily complete each party's R&D tasks.
- 3) Cooperative research projects. In some cases, it may be most efficient for NRC-RES and EPRI to cooperate in performing certain research tasks or projects. These projects will be identified by mutual agreement of both organizations. Areas in which coordinated or cooperative research activities may be undertaken include but are not limited to those summarized below. In each case, and especially with regard to research identified as potentially subject to joint activities, the decision regarding the extent of collaboration will be based upon mutual agreement.
 - a) Aging and Degradation of Systems, Structures, and Components (including reactor pressure vessels and core internal materials, cables and concrete)
 - i) Example areas of cooperation include but are not limited to:
 - a. Information exchange related to domestic and international research activities and operating experience to address and evaluate the status of materials degradation issues in—including but not restricted to—metallic and non-metallic components, concrete structures, and cable insulation. Particular focus will be on issues identified in the Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR (NUREG-2191) and supporting SLRGDs such as NUREGs 2192, 2221, 2222, and follow-on SLR interim staff guidance (ISGs) and in the staff requirements memorandum on SECY 14-0016 (ADAMS Accession No. ML14241A578) on SLR.
 - b. Investigations of aging management through information exchange and data sharing, advances in the development and application of aging management methods, and demonstration of technical tools.

- c. Research activities to study crack initiation due to PWSCC in nickel-based alloys including review and reporting on the test program by an Expert Panel.
 - d. Research activities and information exchange related to PWSCC crack growth in nickel-based alloys. An Expert Panel is planned to review available PWSCC data generated by NRC-funded research, EPRI-funded research, and other international programs and to identify the appropriate attributes for data to be considered for independent component integrity evaluations.
 - e. Research activities related to neutron absorber materials used in wet and dry storage including analyses, evaluations and testing of known and potential degradation mechanisms, and monitoring approaches for neutron absorber material aging management.
 - f. Research activities to study degradation of reactor pressure vessels (RPVs) and vessel internal components due to exposure to the reactor operating environment (temperature, pressure, coolant chemistry, and neutron radiation).
 - g. Coordination of efforts to harvest materials from selected structures and components from decommissioning reactors to provide research specimens for aging management programs.
- b) NDE and condition monitoring for aging management (e.g., metals, concrete, and cables)
- i) Cooperative research on all aspects of nondestructive examination including methods, procedures, equipment, and personnel. The overall objectives of this effort are to identify and evaluate the effectiveness of NDE methods in detecting and characterizing flaws, to evaluate the reliability of NDE methods for selected examinations, and to evaluate aspects of inspector qualifications.
 - ii) Example areas of cooperation for NDE research include but are not limited to inspection of cast austenitic stainless steel; Ultrasonic testing in lieu of radiographic testing for repairs, replacements, and modification; documentation of the basis for ASME Section XI, Appendix VIII; and NDE modeling.
 - iii) The NRC and EPRI will continue to participate in joint international and domestic activities on topics of mutual interest, such as assessing the reliability of NDE for inspection of nuclear power plant components. For example, EPRI is a participant in the NRC's international Program for the Investigation of Non-Destructive Examination (PIONIC). Execution of individual tasks by the NRC and by EPRI will be contingent upon available funding and other resources.
 - iv) With regard to electrical cables, EPRI and NRC-RES will continue cooperative research activities to assess and evaluate condition-monitoring methods on electrical cables subjected to aging under normal operating conditions and design basis event (accident) conditions with the following research objectives:
 - a. Evaluate the adequacy of condition monitoring methods for cables in a harsh and mild (submerged) environment and validate service life predictions.
 - b. Evaluate condition-based qualification methodologies and acceleration factors for simulation of aging that are described in widely used voluntary consensus standards.
 - c. Evaluate current test methods and aging factors for cables in a submerged environment as well as conduct research to identify and evaluate new methodologies.
 - v) Example areas of cooperation include but are not limited to assessing condition-monitoring methods and testing cables that are representative of those used in commercial nuclear power plants including:
 - a. For cables in mild and harsh environments, the NRC will examine laboratory-aged cables under normal operating conditions and simulated accident conditions, assessing the effectiveness of condition-monitoring techniques.

- c) **Repair/Replacement of Components**
 - i) Example areas of cooperation include but are not limited to exchange of operating experience and other information related to the performance of repaired components in nuclear power plants (NPPs), the feasibility of replacing aging plant components, and identification of components of interest to be harvested from decommissioning NPPs for research purposes.
 - ii) EPRI and NRC-RES also may investigate the feasibility of applying advanced technologies, such as advanced manufacturing techniques, to effect repairs of degraded components.
- d) **Joining and Welding**
 - i) Example areas of cooperation include but are not limited to evaluating welding techniques for steels and nickel base alloys used in NPPs, including joining carried out in fabrication and weld repairs, and characterizing the structures, residual stresses, and performance of welds during extended operation. Particular focus may be placed on welding of irradiated materials such as those used in RPV internal structures and components.
 - ii) EPRI and NRC-RES will exchange information in support of standards development for joining and welding such as revisions to the ASME Boiler and Pressure Vessel Code.
- 4) **Other Parties**. Recommendations concerning the participation of other parties (whether domestic or international) will be jointly developed and reviewed with NRC/RES and EPRI management. All technical interactions will be managed through a designated point of contact for each party. All EPRI data and materials subject to commercial or other use restrictions will be submitted to the NRC under a general affidavit addressing all documents, data, and materials to be shared with the NRC pursuant to this Addendum and requesting that such documents, data, and materials be withheld from disclosure to the public pursuant to Title 10, Section 2.390, of the *Code of Federal Regulations* (10 C.F.R. 2.390) as provided in the MOU.
- 5) **Seminars/Workshops**. Subject to continuing stakeholder needs and interest, NRC-RES and EPRI will collaborate to conduct seminars and workshops relating to the technical areas outlined in this addendum.
- 6) **Future Collaboration Areas**. Additional research activities related to advanced nuclear technologies may be identified and pursued jointly as appropriate. EPRI and RES will continue to jointly participate, when appropriate, in the identification of additional areas of mutual interest for joint collaborative activities that will be added to this Addendum.

IV. Period of Performance

The initial period of performance will be from the Effective Date through September 30, 2026, to be extended or revised in writing if mutually agreeable to EPRI and the NRC.

V. Project Direction and Coordination

All technical interactions will be managed through designated points of contact for each party for each technical area (the "Project Contacts"). Technical meetings to coordinate this effort and to discuss project progress will be arranged through the respective Project Contacts. The Project Contacts are:

<p>NRC:</p> <p>Christopher Cook, Chief Instrumentation and Controls and Electrical Engineering Branch Christopher.Cook@nrc.gov</p> <p>Steve Ruffin, Chief, Materials Engineering Branch Steve.Ruffin@nrc.gov</p> <p>Raj Iyengar, Chief Reactor Engineering Branch Raj.Iyengar@nrc.gov</p> <p>Meraj Rahimi, Chief Regulatory Guide and Programs Branch Meraj.Rahimi@nrc.gov</p> <p>Dogan Seber, Chief Seismic, Geotechnical, and Structural Engineering Branch Dogan.Seber@nrc.gov</p> <p>Office of Nuclear Regulatory Research · U.S. Nuclear Regulatory Commission 11545 Rockville Pike, MS TWFN 09-A60M Rockville, MD 20852</p>	<p>EPRI:</p> <p>Emma Wong Principal Technical Leader Innovation and Long Term Operations Electric Power Research Institute ewong@epri.com</p> <p>PWSCC: Jean Smith Program Manager jmsmith@epri.com</p> <p>Reactor Pressure Vessel: Elliot Long Principal Technical Leader elong@epri.com</p> <p>NDE and Condition Monitoring: Greg Selby Sr. Technical Executive gselby@epri.com</p> <p>Andrew Mantey Principal Technical Leader amantey@epri.com</p> <p>Repair / Replacement, Joining / Welding: Greg Frederick Program Manager gfrederi@epri.com</p> <p>Neutron Absorbing Materials: Hatice Akkurt Technical Executive hakkurt@epri.com</p>
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VI. Cost and Schedule

EPRI and the NRC are responsible for their respective costs in implementing this Addendum. This Addendum does not create any binding obligation or enforceable right of action of any kind on the part of either party. This Agreement does not obligate any funds and is subject to the availability of appropriated funds.


VII. Disputes

If a dispute arises out of or relating to this Addendum or any breach thereof, the parties will first attempt to settle the dispute through direct negotiation between the Project Contacts. If such a dispute cannot be settled by the Project Contacts, the dispute shall be submitted to the Senior Management Contacts (as defined in the MOU) for resolution.

AGREEMENT

 9/28/2021

Raymond Furstenau Date
Director of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission

 9/28/2021

Dr. Rita Baranwal Date
Vice President and Chief Nuclear Officer
Electric Power Research Institute

RENEWAL OF ADDENDA
to
MEMORANDUM OF UNDERSTANDING
between
U.S. NUCLEAR REGULATORY COMMISSION
and
ELECTRIC POWER RESEARCH INSTITUTE, INC.
on
COOPERATIVE NUCLEAR SAFETY RESEARCH

Renewal of XLPR and Steam Generator Tube Base Research Program

This confirms the desire to continue cooperative activities under the Addenda on the Maintenance, Support, and Distribution of the xLPR Version 2 Code (ADAMS Accession No. [ML20073F692](#)) and Steam Generator Tube Base Research Program (ADAMS Accession No. [ML20227A051](#)). The xLPR Version 2 (xLPR) Addendum expiration is hereby extended to September 30, 2026, and the Steam Generator Tube Base Research Program (TIP-6) Addendum expiration remains December 31, 2023. The contact information for NRC and EPRI staff is as follows xLPR and TIP-6:

xLPR:

NRC:

Matthew Homiack, Materials Engineer
Component Integrity Branch
Division of Engineering
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555
301-415-2427
Matthew.Homiack@nrc.gov

EPRI:

Craig Harrington
Technical Executive, Materials Reliability
Program
Mandalay Tower III
201 East John Carpenter FWY, Suite 800
Irving, TX 75062
charrington@EPRI.com

TIP-6:

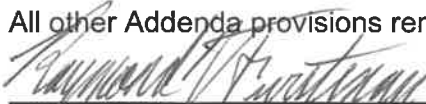
NRC:


Patrick Purtscher, Materials Engineer
Materials Engineering Branch
Division of Engineering
Office of Nuclear Regulatory Research
Nuclear Regulatory Commission
Washington, DC 20555
301-415-3942
Patrick.Purtscher@nrc.gov

EPRI:

James Benson
Senior Technical Executive, Steam
Generator Management Program
1300 West WT Harris Boulevard
Charlotte, NC 28262
jbenson@epri.com

All other Addenda provisions remain in full force and effect.


Raymond Furstenau 9/28/2021
Date
Director of Nuclear Regulatory
Research
U.S. Nuclear Regulatory Commission


Dr. Rita Baranwal 9/28/2021
Date
Vice President and Chief Nuclear
Officer
Electric Power Research Institute