

The background of the cover is a photograph of a large industrial facility, likely a nuclear reactor, with a prominent white dome structure. The image is partially obscured by large, semi-transparent geometric shapes in shades of blue and grey, creating a modern, architectural aesthetic. The overall color palette is dominated by deep blues and greys, with accents of yellow and white.

# NATIONAL REACTOR INNOVATION CENTER ANNUAL REPORT

**2025**

INL/RPT-25-86113  
Revision 0

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## DIRECTOR'S MESSAGE

It is my privilege to present this year's annual report for the National Reactor Innovation Center (NRIC). As we complete our sixth year of operation, NRIC has achieved unprecedented momentum in accelerating the testing and demonstration of advanced nuclear technology by providing critical access to national laboratory assets and expertise. FY 2025 marked a transformative year for NRIC, highlighted by several groundbreaking accomplishments that directly advance our mission to bridge the gap between concept and commercialization for advanced nuclear technology deployment.

### **Historic Reactor Selections and Construction Progress**

Most notably, in July 2025, NRIC and DOE announced conditional selections for our first DOME experiments—calling them "the first of their kind in the world" and a key step to "fast-track the deployment of American microreactor technologies." This milestone represents the culmination of years of strategic infrastructure development and partnership building with industry leaders.

Our construction efforts have accelerated dramatically. DOME construction advanced its completion timeline by 11 months—from February 2027 to March 2026—to accommodate a potential reactor experiment in Spring 2026. Similarly, the LOTUS test bed project achieved Critical Decision 3A approval, authorizing long-lead procurement actions that will accelerate overall project completion by approximately one year.

### **Infrastructure and Capability Expansion**

NRIC continues to fill gaps identified by industry in experimental infrastructure. The Molten Salt Thermophysical Examination Capability (MSTEC) nears completion and will become the only facility in the world offering comprehensive characterization capabilities for irradiated fuel salts—a critical capability for advancing molten salt reactor deployment.

Our Virtual Test Bed expanded to 64 advanced reactor simulation use cases, attracting over 800 new users and establishing NRIC as a premier resource for computational reactor analysis.

### **Digital Innovation Leadership**

NRIC is leading digital transformation efforts through deployment of a comprehensive digital engineering ecosystem, including digital twins for nuclear facilities. We are leveraging this ecosystem by incorporating artificial intelligence tools to revolutionize how safety documentation is developed and reviewed, promising significant cost and schedule improvements for future reactor deployments.

### **Looking Forward**

The progress NRIC made in FY 2025 positions us to deliver on our foundational promise: demonstrating two private advanced reactors by 2026 and 2028. With DOME approaching operational readiness and LOTUS construction beginning, NRIC is uniquely positioned to support the nuclear renaissance our nation needs.

As we enter FY 2026, NRIC stands as a testament to what can be achieved when the world-class capabilities of the national laboratory system are strategically aligned with private sector innovation. Our success will not only inspire confidence in advanced nuclear technologies but will re-establish the United States as the undisputed global leader in nuclear energy innovation.

The NRIC team remains energized and committed to enabling the abundant, affordable, and reliable nuclear energy that will power America's future.

Best Regards,

Brad Tomer, NRIC Director

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## ACRONYMS

Acronym	Definition
ABS	American Bureau of Shipping
ACI	American Concrete Institute
ACTI	Advanced Construction Technology Initiative
AI	Artificial Intelligence
ANL	Argonne National Laboratory
ASME	American Society of Mechanical Engineers
BPVC	Boiler Pressure Vessel Code
CD	Critical Decision
CDE	Critical Decision Equivalent
CGD	Commercial Grade Dedication
CM	Configuration Management
CVS	Containment Ventilation System
DEEP	Detailed Engineering and Experiment Planning
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy, Headquarters
DOE-ID	U.S. Department of Energy, Idaho Operations Office
DOE-NE	U.S. Department of Energy, Office of Nuclear Energy
DOME	Demonstration of Microreactor Experiments
DPSC	Diaphragm Plate Steel Composite
E&I	Equipment and Infrastructure
EPRI	Electric Power Research Institute
FEED	Front-End Engineering and Experiment Design
FNPP	Floating Nuclear Power Plants
FY	Fiscal Year
GFE	Government Furnished Equipment
GTA	General Test Assembly
GUI	Graphical User Interface
HRS	Heat Removal System
I&C	Instrumentation and Controls

<b>Acronym</b>	<b>Definition</b>
ICE	Independent Cost Estimate
INL	Idaho National Laboratory
ISO	International Organization for Standardization
JIP	Joint Industry Partnership
LLP	Long-Lead Procurement
LOTUS	Laboratory for Operation and Testing in the United States
M&S	Modeling and Simulation
METL	Mechanisms Engineering Test Loop
MFC	Materials and Fuels Complex
MNAG	Maritime Nuclear Application Group
MOOSE	Multiphysics Object Oriented Simulation Environment
MSR	Molten-Salt Reactors
MSTEC	Molten Salt Thermophysical Examination Capability
NASA	National Aeronautics and Space Administration
NEAMS	Nuclear Energy Advanced Modeling and Simulation
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act
NNSS	Nevada National Security Site
NQA	Nuclear Quality Assurance
NRC	U.S. Nuclear Regulatory Commission
NRIC	National Reactor Innovation Center
NSP	Nonproliferation Stewardship Program
OPC	Other Project Costs
ORNL	Oak Ridge National Laboratory
PDSA	Preliminary Documented Safety Analysis
PEP	Project Execution Plan
PNNL	Pacific Northwest National Laboratory
R&D	Research and Development
RFP	Request for Proposal
RIPB	Risk-Informed Performance-Based
STAND	Siting Tool for Advanced Nuclear Development

Acronym	Definition
THETA	Thermal Hydraulic Experimental Test Article
TPM	Technical Program Manager
U.S.	United States
USNC	Ultra Safe Nuclear Corporation
VTB	Virtual Test Bed
ZPPR	Zero Power Physics Reactor

# National Reactor Innovation Center Annual Report FY 2025

## 1. PROGRAM OVERVIEW

Established in August 2019, the National Reactor Innovation Center (NRIC) is a national United States (U.S.) Department of Energy (DOE) program designed to partner with industry and national laboratories to bridge the gap between advanced nuclear technology concepts and commercial deployment. NRIC accomplishes this through building or enhancing existing DOE infrastructure to support testing of materials, components, and reactor systems that industry requires.

### 1.1 NRIC Mission and Approach

NRIC's core mission is expediting advanced nuclear energy development by connecting private-sector technology developers with the world-class capabilities of the DOE national laboratories. The program provides U.S. industry access to physical infrastructure at DOE national laboratories for testing and demonstrating reactor concepts, while working closely with DOE-Nuclear Energy (DOE-NE) who grants access to regulatory and financial support for commercializing nuclear technologies.

NRIC is executing this work through establishment of four new experimental facilities and two large reactor test beds for integrated technology demonstrations and experimentation. NRIC's immediate goal is the demonstration of two private advanced reactors, one in 2026 and one in 2028, with the broader objective of establishing abundant, affordable energy, and re-establishing U.S. leadership in advanced nuclear energy.

NRIC activities align with six core principles that guide decision-making: reduced timeframe to achieve safe reactor operation; reduced deployment costs; improved predictability through reliable timeframes and cost estimates to build stakeholder confidence and reduce deployment risks; improved safety performance; increased reliability and efficiency; and leveraging national laboratory capabilities for maximum partner benefit.

### 1.2 Operations and Partnerships

NRIC is headquartered at Idaho National Laboratory (INL), in Idaho Falls, Idaho, leveraging DOE's premier nuclear energy lab. Although INL is known as the lead for nuclear energy, it also retains expertise in national security research and testing, energy and environmental research, analytical chemistry, space, security power systems, and applied and digital engineering. NRIC draws upon these diverse capabilities and partners with complementary INL programs to meet the needs of industry partners. The large amount of well-characterized land, existing facilities, and nuclear expertise make INL the ideal location for NRIC's primary operations.

In addition to partnerships with industry, NRIC collaborates with key DOE national laboratories including Oak Ridge National Laboratory (ORNL), Pacific Northwest National Laboratory (PNNL), Argonne National Laboratory (ANL), and Los Alamos National Laboratory (LANL), as well as with



Work Package Title	FY 2024 Carryover (\$K)	New FY 2025 Funding (\$K)
Demonstration Reactor Siting Environmental Regulatory Support –ORNL	\$ 48	\$ 0
Demonstration Reactor Siting Environmental Regulatory Support – NNS	\$ 27	\$ 0
Analysis for Deploying Nuclear Reactors on Federal Land – ANL	\$ 0	\$ 30
Analysis for Deploying Nuclear Reactors on Federal Land – ORNL	\$ 0	\$ 100
<b>Demonstration Reactor Infrastructure</b>		
Demonstration of Microreactor Experiments (DOME) Test Bed Equipment and Infrastructure (E&I) Support	\$ 16,909	\$ 12,000
DOME Construction	\$ 28,597	\$ 20,050
Front-End Engineering and Experiment Design (FEEED)	\$ 298	\$ 2,550
Detailed Engineering and Experiment Planning (DEEP)	\$ 5,000	\$ 1,380
LOTUS Design and Construction other project cost (OPC)	\$ 2,440	\$ 2,000
LOTUS Design and Construction total estimated cost (TEC) (NE-3 Funded)	\$ 42,756	\$ 16,112
<b>Regulatory and Economic Risk Reduction</b>		
Regulatory and Economic Risk Reduction	\$ 858	\$ 1,100
Development and Demonstration of Digital Engineering Systems	\$ 435	\$ 2,400
Nuclear Quality Assurance (NQA)-1 Feasibility Study	\$ 600	\$ 0
Advanced Construction Technology Initiative (ACTI)	\$ 24,660	\$ 8,000
<b>Experimental Infrastructure</b>		
Mechanisms Engineering Test Loop (METL) Operations, Testing, Maintenance, and Improvements	\$ 1,965	\$ 2,400
Molten Salt Thermophysical Examination Capability (MSTEC)	\$ 2,533	\$ 900
Virtual Test Beds (VTB) – INL	\$ 415	\$ 1,200
Digital Engineering and VTB Support – ANL	\$ 214	\$ 850
<b>Integrated Energy Systems and Nonelectric Applications</b>		
Maritime Applications of Nuclear Energy Studies – INL	\$ 686	\$ 1,200
Maritime Applications of Nuclear Energy Studies – ORNL	\$ 215	\$ 0
Maritime Applications of Nuclear Energy Studies – PNNL	\$ 154	\$ 0

### 3. NRIC-INITIATED PROJECTS

NRIC projects are specifically designed to address critical challenges in advanced reactor demonstration, including safety, siting, environmental impacts, technological assessments, and reactor demonstrations. Through guidance on siting, stakeholder engagement, advanced technology implementation, and regulatory requirements, NRIC ensures timely implementation of advanced concepts while providing the foundation for future U.S. advanced reactor development.

To advance these objectives, NRIC made significant progress on existing projects and initiated new mission-critical projects in FY 2025, as detailed in Table 1.

#### 3.1 Program Management

<b>Project Start Date:</b>	October 2020	<b>Work Package Manager:</b>	AnnMarie Marshall
		<b>Work Package Number:</b>	RC-25IN010101

#### Objectives

The objective of this work package is to execute the NRIC Program while ensuring responsiveness to and coordination with industry and maintaining overall program performance. High-level objectives include:

- Implement the NRIC strategy
- Build an effective, agile, and scalable NRIC organization.
- Strengthen and develop program coordination
- Establish processes enabling innovators to access facilities, sites, materials, and expertise for advanced nuclear technology demonstration
- Define technical work scope, deliverables, reporting, and schedules for NRIC activities

In 2020, NRIC conducted a Gap Assessment to identify missing national laboratory capabilities needed for industry reactor concept demonstration. The assessment considered 37 reactor concepts and identified 20 fundamental problems.

NRIC initiated several efforts to close these gaps by providing access to capabilities, facilities, and tools essential for new reactor technology demonstration (see Table 1 in INL/EXT-20-59834). The gap assessment confirmed that commercial deployment of advanced nuclear technology can be accelerated through NRIC's mission to inspire stakeholders and the public, empower innovators, and deliver successful outcomes through efficient partner and resource coordination.

#### Progress and Accomplishments

In FY 2024, NRIC initiated an update to the 2020 Gap Assessment, completing it in FY 2025. The updated assessment identifies areas where NRIC can most effectively address current and predicted gaps in testing programs, laboratory facilities, and capabilities. As an agile and learning organization, NRIC recognizes that reactor developers' needs have evolved since its

establishment. Through this assessment, NRIC engaged with 37 reactor developers, 19 National Technical Directors, and seven national laboratories to determine needs and capabilities, subsequently prioritizing gaps to better support industry reactor demonstrations. The assessment focuses resources on the industry's most impactful issues. The updated Gap Assessment Report (INL/RPT-24-82493) was submitted to DOE Headquarters in January 2025 for review and comment.

In September 2025, NRIC completed its FY 2025 Annual Report (INL/RPT-25-86113), detailing major activities, projects, and accomplishments for the fiscal year.

## Looking Ahead

In FY 2026, the NRIC Program Management work package will fund the NRIC Director and Chief Operations Officer positions while continuing to provide program oversight and guidance. NRIC will develop strategies to address key findings from the Gap Assessment. These findings represent priority needs identified across the industry, and developing strategies to address them will advance NRIC's collaboration efforts with reactor developers.

## 3.2 NRIC Operations

<b>Project Start Date:</b>	October 2021	<b>Work Package Manager:</b>	AnnMarie Marshall
		<b>Work Package Number:</b>	RC-25IN020101

## Objectives

The Operations work package encompasses the necessary INL and subcontractor support staff who manage and execute NRIC activities and develop associated processes. These staff members provide administrative assistance; program management; project coordination; configuration management (CM); engineering support; scheduling, budgeting, software licensing, risk management, communications, and program controls. NRIC staff collaborate internally within INL, with national laboratory program partners, and externally with industry experts to develop a holistic approach for executing the NRIC mission.

The cross-functional NRIC team includes staff across diverse engineering disciplines, complemented by world-class expertise in the deployment of new technology, communications, and project management. The objective is for NRIC to maintain an aggressive schedule for demonstrating advanced nuclear reactors while responsibly managing technology and project risk, as well as the complex interfaces among private-sector collaborators and nuclear reactor systems.

## Progress and Accomplishments

NRIC made significant progress in recruiting staff to support project execution. The competitive labor market resulted in NRIC losing employees to promotions and higher compensation opportunities elsewhere. In FY 2025, NRIC brought on three new technical program managers (TPMs). See the latest NRIC organization chart provided in Appendix A.

The Annual NRIC Program Review was held on April 1-3, 2025, at INL, and brought together key participants from 39 companies, four national laboratories, six universities, and four government

agencies. This year's program review demonstrated significant engagement with 230 participants registering to attend, of which 150 attended in person. Photos from the event are shown in Figure 1.

The NRIC website was updated to improve user experience, including:

- New facility pages with associated construction timeline
- Increased visibility on events NRIC lead or participated in
- Migrated the NRIC website to a new platform managed internally by INL.

## Looking Ahead

The NRIC Operations work package will continue to provide program support to all NRIC projects in the areas of CM, financial and administrative support, document and records management support, and software licensing. NRIC will again host the NRIC Annual Program Review.



Figure 1. Attendees and Presenters at the April 2025 Annual NRIC Program Review.

### 3.3 Collaboration Initiatives

Project Start Date:	October 2021	Work Package Manager:	Adrian Collins
		Work Package Number:	RC-25IN020201

#### Objectives

NRIC aims to accelerate the testing and demonstration of advanced nuclear energy technology in the U.S by collaborating with advanced nuclear technology developers, regulators, national laboratories, and end users to deploy safe, secure, and environmentally beneficial technologies. NRIC's program utilizes a collaboration strategy to guide industry engagements, providing guidance on collaborating with advanced nuclear technology developers to ensure external engagement opportunities are analyzed for potential program benefits.

#### Progress and Accomplishments

NRIC made significant progress in collaborations throughout FY 2025, including identifying and supporting new collaborations for emerging markets, and identifying gaps across the NRIC program to further support reactor developers. Key milestones accomplished in FY 2025 include:

- May 2025: Issued a report on the Minimal Maintenance of NRIC Collaboration Tools (INL/RPT-25-85246), identifying the minimal maintenance needed for collaboration tools to support reactor developers and recommending maintenance activities for the upcoming fiscal year.
- June 2025: Hosted a developer's workshop which virtually on June 23, 2025, with nearly 50 participants, addressing in-depth questions and hosted discussions about conducting demonstrations at INL (see CCN-258445, "Completion of DOE Level 2 Milestone").

NRIC hosted various industry collaboration workshops addressing costs and markets, with a priority on helping industry stakeholders make advanced reactors more cost-effective and delivered on schedule. NRIC led workshops addressing critical supply chain issues for sourcing critical components for nuclear reactors. Additionally, NRIC led efforts addressing new market opportunities for advanced reactors and was able to pull together industry stakeholders to identify their unique testing needs:

- October 2024 – INL Nuclear Power for Data Centers Workshop: NRIC cohosted this workshop in Idaho Falls with INL and Gateway for Accelerated Innovation in Nuclear (GAIN) for data center stakeholders. The workshop provided participants with an understanding of issues facing data center companies (impacts from artificial intelligence [AI], cooling technology, etc.) and facilitated meetings with data center companies and advanced reactor developers to understand the various nuclear technologies.
- October 2024 – Oil & Gas Joint Industry Partnership (JIP) Workshop: NRIC cohosted this workshop with the American Bureau of Shipping (ABS) in Houston, Texas for nuclear, maritime, and oil and gas industry stakeholders to examine testing requirements for nuclear-powered offshore oil & gas applications. The workshop brought together

60 participants and helped forge oil & gas majors' interest in establishing a JIP to minimize risk to advanced nuclear reactor research in the oil & gas industry.

## Next Steps

The following steps will determine the appropriate actions regarding collaboration tools and develop future collaborative efforts.

- **Website:** Continue upgrading the NRIC website and leverage INL's internal website management group to aid site updates. NRIC may evaluate future contractor support based on the effectiveness of the new INL process.
- **Communications:** Continue conducting recurring meetings with developers' communications teams to ensure clear messaging and a coordinated effort to highlight progress made with NRIC's support for reactor demonstrations.

NRIC will develop a communications strategy to increase awareness, build trust, engage industry partners, showcase progress, and position NRIC as a leader in the nuclear energy sector.

- **New Collaborations:** Establish a recurring meeting with NRIC TPMs to identify new collaborations and progress with industry partners. Collaborate with the Nonproliferation Stewardship Program (NSP) and work to integrate NSP priorities into NRIC's testing development.
- **Off-Site Support:** Given DOE's recent announcement to support reactor developers demonstrating reactors not on DOE sites, NRIC will develop a strategy for supporting these industry partners, outlining NRIC's responsibilities in aiding developers through the DOE authorization process.

## 3.4 Siting Tool for Advanced Nuclear Development (STAND)

<b>Project Start Date:</b>	October 2020	<b>Work Package Manager:</b>	Matthew Bucknor Femi Omitaomu Dennis Kelly
		<b>Work Package Number:</b>	RC-25AN020202 RC-25OR020203 RC-25NN020204

## Objectives

ANL, in partnership with INL, ORNL, and the University of Michigan, has developed STAND. STAND provides siting guidance based on energy policy, labor considerations, political will, popular attitude, and on NRC Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Plants Parameters." A preference model within STAND enables comparison between multiple potential sites based on user preferences. STAND offers vendors, utilities, and stakeholders a valuable tool for evaluating siting for various nuclear facilities in support of the DOE Advanced Reactor Demonstration Program (ARDP) and other DOE-NE initiatives.

**ANL Objectives:** Project coordination efforts, assisting in STAND development and testing, promotion of the tool, providing assistance for STAND small group training sessions, and providing technical support for the Argonne preference model.

**ORNL Objectives:** Continuing coordination on STAND with ANL, INL, and the University of Michigan as well as assisting vendors, utilities, and other stakeholders in the use of STAND and/or to add insights directly from the ORNL siting tool: Oak Ridge – Siting Analysis for Power Generation Expansion (OR-SAGE).

Overall project direction and final decision-making is made by the NRIC Collaboration Initiatives TPM. See Figure 2 for some images from the STAND tool.

## Progress and Accomplishments

The team continued STAND maintenance activities including updating data within the tool, adding additional capabilities/data layers, managing users, and providing small group training sessions for industry members. In FY 2025, the STAND team conducted 13 small group training sessions and continued activities to promote STAND and interface with users.

As of July 2025, STAND had 901 registered users compared to 529 a year ago, representing a 70% increase in user adoption.

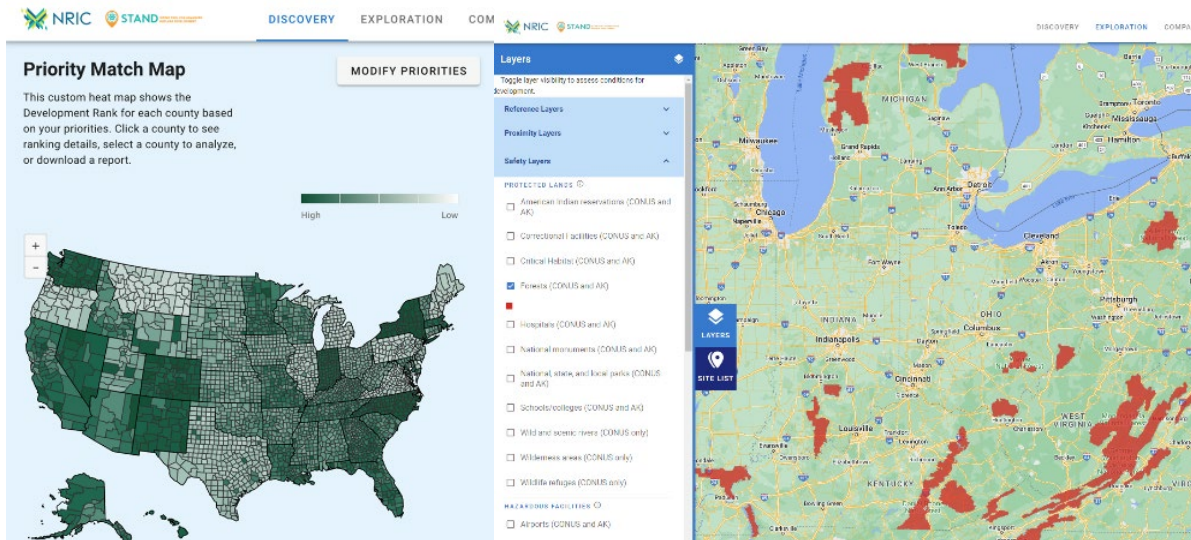


Figure 2. Images from the STAND Tool.

## Next Steps

FY 2026 STAND efforts will focus on continued maintenance and promotion activities, ongoing support of the user base, expanded tool capabilities, hosting new user training sessions as needed, and possible tool development activities including additional expansion of STAND to include more data layers and metrics.

## 3.5 Demonstration Reactor Infrastructure

### 3.5.1 DOME Test Best Operation Support Equipment and Infrastructure

Project Start Date:	March 2021	Work Package Manager:	Josh Gillespie
		Work Package Number:	RC-25IN020301

#### Objectives

This work package provides the necessary equipment, infrastructure, requirements, analysis, and guidelines to facilitate safe and affordable testing of advanced nuclear reactors in DOME. Key capabilities include fresh fuel storage and transportation at INL, reactor fueling, reactor supplemental shielding, irradiated fuel reactor removal from DOME, reactor handling system, reactor teleoperated equipment, and a reactor cool-down facility.

The primary focus for FY 2025 is to:

- Finalize designs, place procurements, and begin fabrication of operation support equipment
- Further detailed plans for post-experiment reactor activities
- Develop an integrated project for the entire DOME Ecosystem.

#### Progress and Accomplishments

Milestones accomplished in FY 2025 include:

- December 2024: NRIC released the DOME Overhead Remote and Teleoperated Equipment Specification (SPC-70990), completing milestone M3RC-25IN02030111 (CCN 257640).
- August 2025: NRIC submitted the Initial Plan for Reactor Removal and Decommissioning (M3RC-25IN0203019), documented in NRIC PLN-7043, “NRIC DOME Post-Irradiation Fuel Management Plan.” Additionally, NRIC initiated the Reactor Anchoring Platform (RAP) procurement (M3RC-25IN0203017), submitted the updated GDE-55086, “DOME User Guide” incorporating lessons learned from the DEEP project (M2RC-25IN02030115), and initiated the reactor supplemental shielding procurement (M2RC-25IN0203015).
- September 2025: NRIC finalized the Thermal Sleeve Design (M3RC-25IN02030113).

Major Program Milestones: On July 1, 2025, NRIC, along with DOE, announced conditional selections for DOME experiments, calling them “the first of their kind in the world” and a key step to “fast-track the deployment of American microreactor technologies” amid growing demand for “more abundant, affordable, and reliable power.”

This year brought many changes to the overall scope and plan for DOME Test Bed Operation Support E&I, driven by accelerated DOME construction and the conditional selection of two DOME reactor experiments. An overall DOME Ecosystem schedule has been drafted and incorporated to reflect these changes.

## Next Steps

In FY 2026, NRIC will complete the procurements of the needed DOME Test Bed Operation Support E&I, transition focus to ensuring the overall DOME Ecosystem in support of the two conditionally selected developer experiments, establish steady-state DOME operations capabilities, and prepare infrastructure for future experiments.

### 3.5.2 NRIC DOME Construction

Project Start Date: October 2020	Work Package Manager: Chance Price
	Work Package Number: RC-25IN020302

## Objectives

NRIC's DOME project restores a portion of the capabilities of the Experimental Breeder Reactor-II (EBR-II) facility, which is located at the INL Materials and Fuels Complex (MFC), and refurbishes it to host advanced reactor demonstrations and experimental reactors up to 20 MWth fueled with high-assay low enriched uranium (HALEU). The facility provides a safe path for reactors to achieve initial criticality for the first time.

By leveraging existing facilities originally constructed for nuclear work, DOME offers opportunities to:

- Enable testing and demonstration of reactor concepts by the private sector
- Validate advanced nuclear reactor concepts
- Resolve technical challenges of advanced nuclear reactor concepts
- Provide general R&D to improve innovative technologies
- Minimize potential adverse impacts with existing programs
- Balance research, development, and demonstration activities with protection and preservation of human health and the environment while ensuring compliance with applicable laws, regulations, and other requirements.

## Progress and Accomplishments

DOME construction underwent several scope changes and schedule acceleration to accommodate the Radiant experiment in April 2026. This resulted in an 11-month acceleration from the previously planned completion date of February 2027 to March 2026. Additionally, the Polar Crane refurbishment was added to the Construction scope and accelerated to March 2026.

Significant progress toward a functioning DOME test bed was accomplished in FY 2025. Figure 3 shows pictures of DOME Construction accomplishments throughout FY 2025.

DOME Construction accomplished the following in FY 2025:

- November 2024: NRIC initiated procurement of the DOME polar crane repairs (M2RC-25IN0203028)
- March 2025: NRIC completed Estech's scope on the control room construction (M2RC-25IN0203023)
- July 2025: NRIC initiated the DOME hatch installation (M2RC-25IN0203022)
- September 2025: NRIC completed NRIC DOME Construction Progress Report (M3RC-25IN0203024), completed the procurement of DOME Test Bed Government Furnished Equipment (GFE) (M2RC-25IN0203026).

## Next Steps

Construction will continue into FY 2026, with operational readiness targeted for Q3 of FY 2026.



*DOME utility installation*



*Yard grading at DOME site*



*DOME hatch rough cut*



*DOME hatch welding*



*DOME hatch cutting and fit up*



*DOME penetrations with unfinished shotcrete in place*



*DOME developer penetration with shotcrete in place*

*Figure 3. DOME Construction Photos*

### 3.5.3 Front-End Engineering and Experiment Design (FEEED)

Project Start Date: June 2023

Work Package Manager:

Curtis Nielsen

Work Package Number:

RC-25IN020303

#### Objectives

The objective for the FEEED program for advanced reactor testing in the DOME or other test beds is to begin the formal engineering and experiment design process. To initiate the FEEED process, NRIC issued a request for proposal (RFP) in FY 2024 under which developers proposed the scope of work to complete FEEED for their advanced reactor.

NRIC and DOE selected three developers to participate in the FEEED process: Radiant, Ultra Safe Nuclear Corporation (USNC), and Westinghouse. Awards ranged between \$1.2 million and \$1.7 million and include both INL and developer costs associated with the work, with a minimum of a 20% cost share required from the participant.

Work completed during the FEEED process includes:

- Safety documents

- National Environmental Policy Act (NEPA) compliance documentation
- Conceptual design of the advanced test reactor
- Design for integration with the test bed
- Design of the experiment
- An end-to-end estimate of the cost and schedule to complete design, fabrication, and testing.

This work package has supported industry integration requirement workshops with demonstrators as well as development of key guidance materials and explanatory, exploratory, and analytical meetings to support experiment planning.

## Progress and Accomplishments

NRIC completed FEEED work for Radiant and Westinghouse early in 2025, with both companies receiving approval of their Safety Design Strategy (SDS).

USNC filed for bankruptcy in 2025 and was acquired by NANO Nuclear, impacting their participation in the program.

## Next Steps

In FY 2026, NRIC plans to issue a new RFP for new FEEED applicants.

### 3.5.4 Detailed Engineering and Experiment Planning (DEEP)

Project Start Date: 2024	Work Package Manager: Curtis Nielsen
	Work Package Number: RC-25IN020304

## Objectives

NRIC is developing facilities and processes to allow advanced reactor developers to expedite commercialization by providing the infrastructure for hosting fueled reactor experiments developed by industry. NRIC will work with industry partners to complete DEEP for fueled reactor experiments to be tested in NRIC's DOME test bed. Upon successful completion of final design, the Preliminary Documented Safety Analysis (PDSA) will be submitted for DOE review. Approval of the PDSA allows the developer to proceed with procurement, fabrication, and delivery of the reactor experiment.

## Progress and Accomplishments

In FY 2025, Radiant and Westinghouse entered into DEEP, with both developers making significant progress. Both developers completed their 60% designs and received DOE Idaho Operations Office (DOE-ID) approval of their Conceptual Safety Design Report (CSDR). Westinghouse also received

DOE-ID approval of their Preliminary Safety Design Report (PSDR), and has submitted their draft PDSA to the INL for review.

Key milestones include:

- December 2024: NRIC initiated at least one DEEP Project (M2RC-25IN0203041). See Cooperative Research and Development Agreements (CRADAs) 22CRA20 and 23CRU1.
- August 2025: NRIC received the draft PDSA from Westinghouse on their Nuclear Test Reactor (M3RC-25IN0203044).

## Next Steps

Complete Radiant DEEP deliverables and transition Radiant to reactor installation in DOME.

Complete Westinghouse DEEP deliverables and finalize plans for installing Westinghouse's reactor in DOME.

### 3.5.5 NRIC LOTUS Design and Construction OPC

Project Start Date: 2020

Work Package Manager: Jacob Rymer

Work Package Number: RC-25IN020305

## Objectives

The NRIC Laboratory for Operation and Testing in the United States (LOTUS) test bed will reconfigure the Zero Power Physics Reactor (ZPPR) facility at INL's MFC to support experimental reactors up to 500 kWth, including those utilizing fuels requiring an enhanced security posture. The LOTUS test bed will provide a secure, flexible, and technically capable environment for advanced reactor technologies to achieve criticality for the first time within a domestic, Hazard Category (HC)-2 nuclear facility.

LOTUS is designed to:

- Enable physical experimentation of advanced nuclear technologies developed by the private sector
- Resolve technical challenges associated with novel reactor concepts
- Provide general R&D infrastructure to accelerate innovation
- Minimize potential adverse impacts to existing programs and operations
- Ensure compliance with applicable laws, regulations, and environmental protection standards.

The LOTUS test bed directly supports national policy objectives outlined in Executive Orders 14301 and 14299, which call for the modernization of domestic nuclear infrastructure and the acceleration of advanced reactor deployment.

The project is being executed under a tailored governance model authorized by the Secretary of Energy's March 2025 memorandum, which delegates project authority within DOE Order 413.3B for projects less than \$300 million to the national laboratories managed under Management and Operations contracts. As a capital project with a Total Project Cost (TPC) less than \$300 million, DOE Order 413.3B project authority for the LOTUS Project is assigned to the MFC Projects director. This tailored governance model supports a streamlined, risk-informed execution approach for establishing the LOTUS test bed capability. See Figure 4 and Figure 5 for LOTUS images.

## Progress and Accomplishments

In FY 2025, the LOTUS project advanced significantly toward construction readiness. Key accomplishments during the fiscal year include:

### Project Authorization and Procurement:

- Obtained DOE Project Management Executive approval of CD-3A in February 2025, authorizing long-lead procurement (LLP) actions critical to advancing the project schedule. LLP authorization is estimated to accelerate overall project completion by approximately one year based on critical long-lead fabricated items (hatch, security door, containment isolation valves) and other items with challenged industrial supply chains.
- Initiated procurement activities for GFE, including both safety and non-safety systems.
- Solicited and received proposals for the construction subcontract, enabling the development of bid-informed cost and schedule baselines, reducing overall project uncertainty.

### Project Development:

- Conducted comprehensive reconciliation and value engineering process with the apparent construction subcontract awardee to align the construction proposal with project scope and budget targets.
- Completed the development of the Critical Decision Equivalent (CDE)-2/3B project documentation package, including the Project Execution Plan (PEP), risk register updates, and performance baseline documentation (scope, schedule, budget).
- Completed an independent cost estimate (ICE) to support CDE-2/3B approval and full project appropriations; completion of an ICE is a statutorily driven requirement for projects exceeding \$100 million not impacted by changes to DOE Order 413.3B.
- Completed the Project Management Review Board (PMRB) review of the CDE-2/3B package and incorporated associated comments into the final package.

### Key Milestones:

- July 2025: Completed draft documentation to support DOE O 413.3B required independent review(s) on schedule (M2RC-25IN0201013) and the annual memo for use of Other Project Cost (OPC) work on NRIC-LOTUS design efforts (M3RC-25IN0203052).



*Figure 4. ZPPR Prior to LOTUS Redesign.*



*Figure 5. Rendered Model of NRIC LOTUS Test Bed*

## Next Steps

Looking ahead, the LOTUS project will focus on:

- **Congressional Notification and Budget Alignment:** FY 2026 capital funding for the LOTUS Project remains uncertain and could influence the ability to proceed with execution as currently planned. The project will support necessary DOE Congressional notifications to align the project's proposed performance baseline with the DOE Construction Project Data Sheet. The project's revised TPC of approximately \$200 million, which reflects bid-informed

estimates, scope refinement, and market conditions, was not reflected in the FY 2026 President's Budget Request to Congress, requiring alignment prior to proceeding into test bed construction.

- CDE-2/3B Approval: Securing final approval of CDE-2/3B, which will formally establish the project's performance baseline and authorize the start of construction. Prior to approval, DOE consent with the construction subcontract award will be obtained.
- Construction Initiation: Upon CDE-2/3B approval, construction of the LOTUS test bed will be initiated (forecast early FY 2026), including structural modifications to the ZPPR cell, installation of dedicated power and ventilation systems, and establishment of the control room and confinement systems.
- Lifecycle Planning: Begin preparations for operational readiness activities, including development of safety documentation, commissioning plans, and transition-to-operations strategies.

## 3.6 Regulatory and Economic Risk Reduction

### 3.6.1 Regulatory and Economic Risk Reduction

Project Start Date: 2021	Work Package Manager: Jacob Rymer
	Work Package Number: RC-25IN020401

#### Objectives

NRIC continues to align its regulatory strategy with national energy and security goals by reducing regulatory risk and uncertainty for advanced nuclear technologies. In FY 2025, NRIC emphasized integrating AI and digital tools to modernize regulatory workflows and accelerate document development for DOE authorization and future NRC licensing. Key objectives included:

- Completing a comprehensive NEPA analysis to enable multi-experiment operations at the NRIC-DOME test bed.
- Leveraging historical siting evaluations and digital tools to inform future deployment strategies.
- Advancing the Regulatory Risk Reduction Program through digital transformation of safety documentation and regulatory engagement.
- Collaborating with NRC, DOE-HQ, DOE-ID, and industry partners to ensure alignment and transparency in regulatory innovation.

#### Progress and Accomplishments

**NEPA Compliance:** NRIC finalized the Environmental Assessment (EA) and secured a Finding of No Significant Impact (FONSI) for DOME operations (M3RC-25IN0204013). This critical milestone enables streamlined environmental compliance for multiple experiments under a single NEPA framework, significantly reducing the burden on developers and accelerating test bed utilization.

**Siting Evaluation Activities:** No new siting evaluations were conducted in FY 2025; however, NRIC maintained developer support through the STAND digital tool and continued referencing prior siting studies to inform strategic planning.

**Regulatory Risk Reduction:** FY 2025 marked a pivotal year for NRIC's digital transformation of regulatory processes:

- Established a digital framework for DOME to support the development of a digitally generated Documented Safety Analysis (DSA) (M3RC-25IN0204015).
- Launched a pilot experiment to validate the digital transformation of the DOE authorization process (M3RC-25IN0204014).
- Advanced AI integration efforts, though implementation challenges emerged due to the government cloud environment.

- Navigated regulatory uncertainties from evolving executive orders and DOE modifications to existing frameworks, requiring adaptive planning and enhanced coordination.
- Maintained regular engagement with NRC and DOE stakeholders to align digital innovation with regulatory expectations.

## Next Steps

Looking toward FY 2026, NRIC will focus on:

- Complete nuclear safety workflows that support AI integration into DOE authorization processes.
- Publish a comprehensive report detailing cost and schedule improvements achieved through the use of the NRIC digital twin and AI-assisted document generation.
- Collaborate with DOE to develop a Graphical User Interface (GUI) enabling reviewers to interact with digital safety documentation.
- Produce a detailed use report that outlining how the GUI will enhance review efficiency and transparency for both DOE and NRC reviewers.

These strategic efforts will further institutionalize digital tools in regulatory workflows and establish the foundation for future NRC licensing applications.

### 3.6.2 Development and Demonstration of Digital Engineering Systems

Project Start Date:	2021	Work Package Manager:	Thomas Folk Peter Suyderhoud
		Work Package Number:	RC-25IN020403

## Objectives

Digital Engineering represents a holistic approach to complex system design, transitioning from a document-based design process to a data-driven paradigm that integrates data stored in siloed engineering software platforms while transforming project team culture to effectively deploy these techniques. This work scope supports economic risk reduction for NRIC, with NASA data demonstrating that project cost generally correlates with expenditures on systems and digital engineering.

The DoD defines digital engineering as “an integrated digital approach that uses authoritative sources of system data and models as a continuum across disciplines to support lifecycle activities from concept through disposal.” By utilizing digital information to design, engineer, build, operate, and maintain complex projects, digital engineering enables engineering teams to transfer legacy processes to new digital platforms that facilitate integrated development of new models and data sharing.

NRIC continues to execute model-based systems engineering (MBSE) and software integration to support creation of a “Digital Engineering Ecosystem” that incorporates disparate engineering domains. The software connections within this ecosystem constitute the digital thread, which will ultimately enable creation of a digital twin. NRIC defines “digital twin” as a complete digital replica of a physical asset, incorporating both predicted (simulated) and real-time data to support operator decisions.

Under this work scope, NRIC’s Digital Engineering Team provides the enabling mechanism that modernizes and optimizes engineering and management processes supporting other focus areas, rather than producing specific physical products. This work also fosters collaboration with other nuclear energy-focused organizations throughout industry by providing access to software platforms used for data-driven engineering at INL.

## Progress and Accomplishments

### Foundation Development

NRIC Digital Engineering began FY 2025 with strong momentum following several significant milestone completions in FY 2024. The completion of milestone M2RC-24IN0204013: “Complete upgrade to DOME digital twin to include component information (informational digital twin)” implemented a custom-built digital twin user platform. This system enables users to input computer-aided design (CAD) or building information modeling (BIM) files, convert them into interactive environments using game engine technology, associate 3D objects within the environment with engineering data sourced from other NRIC sources (IBM DOORS, Windchill, etc.), and display the information within users’ internet browser. This milestone established the DOME digital twin foundation and establishes further development including predictive simulation and data transfer from the as-built asset.

### Predictive Simulation Integration

Predictive simulation capabilities were further advanced through completion of M3RC-24IN0204016: “Digital Engineering and VTB Integration”. This milestone determined the interface mechanism and provided a proof-of-concept integration between the modeling & simulation (M&S) efforts of the NRIC Digital Engineering team and the Virtual Test Bed (VTB). The DOME shielding model developed under the VTB using Multiphysics Object Oriented Simulation Environment (MOOSE) tools was leveraged to provide direct input to the DOME systems model.

### Strategic Partnership and System Modeling

The plans for FY 2025 primarily focused on expanding the DOME digital twin capabilities and initiating deployment of a digital procedure system for DOME operations. NRIC strategically partnered with ANL to leverage expertise in system modeling and associated instrumentation and control (I&C) logic.

In December 2024, ANL delivered a report defining the DOME system configuration, sets of sensors and actuators, and identified interactions between DOME subsystems (e.g., Heat Removal System [HRS], Containment Ventilation System [CVS], DOME Interior Environment). By June 2025, ANL executed on the plan jointly developed with NRIC and INL, delivering a preliminary model of the HRS and CVS in Dymola. The GUI of the model is shown in Figure 6.

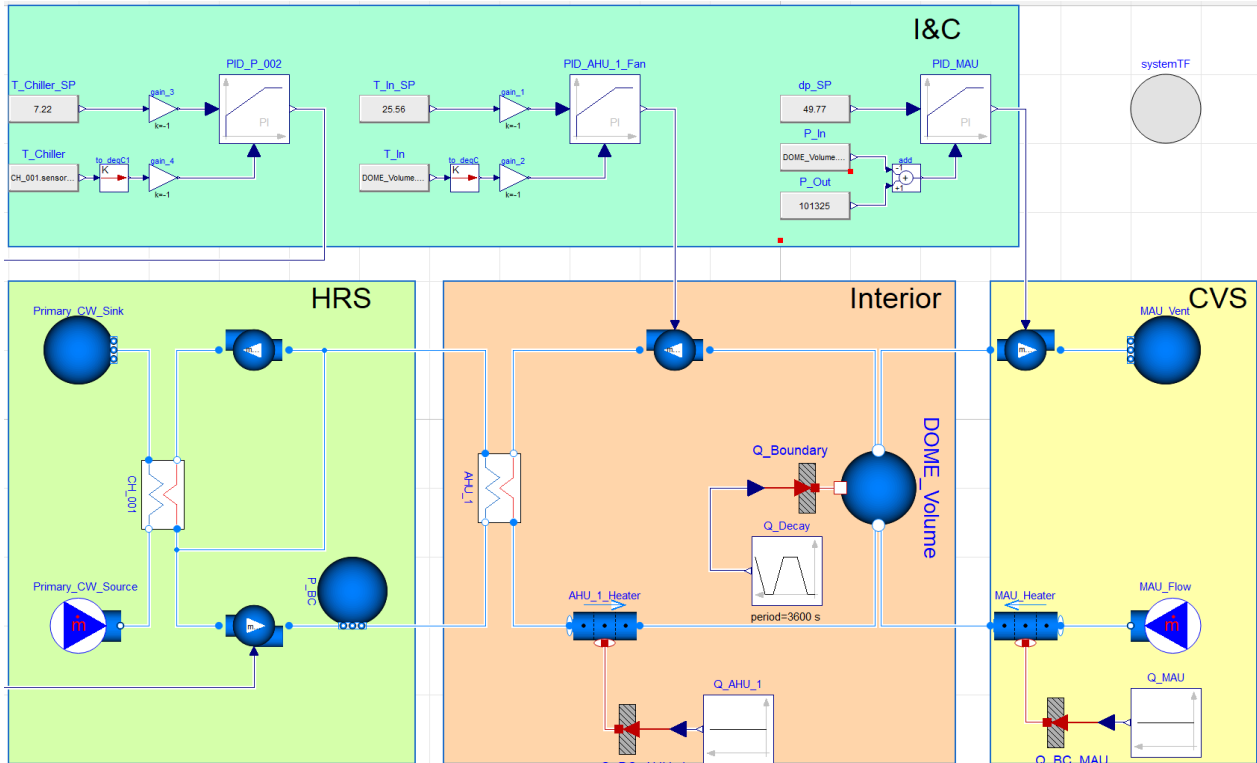


Figure 6. GUI of the preliminary Dymola model with simplified DOME Interior, HRS, CVS, and I&C modules, for transient simulation.

The preliminary model was used to simulate DOME system response to transient heat loads ramping between 100 kWth and 300 kWth. Proportional-integral-derivative controllers are used to simulate equipment control (e.g., blowers, chillers, etc.). Figure 7 demonstrates the capability to maintain constant temperature and pressure within the DOME environment.

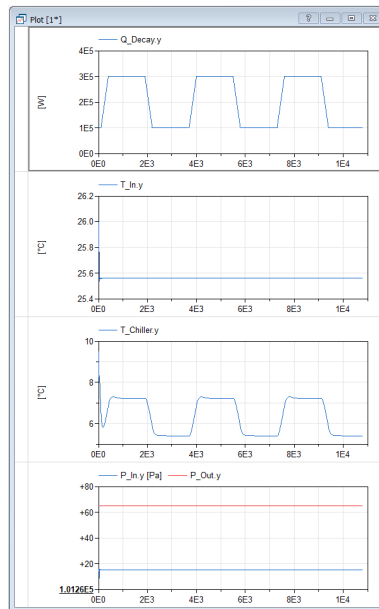


Figure 7: Transient simulation results demonstrating the capability of HRS and CVS.

## Digital Twin Development and Demonstration

In parallel, the INL team continued developing DOME digital twin viewer capabilities and software infrastructure to enable visualization of live measurement data and predictive model results. In April 2025, the Digital Engineering team presented their accomplishments at the NRIC program review in a live demonstration of the software using mixed reality headsets. During the demonstration, users walked through DOME in mixed reality and interacted with systems, structures, and components (SSCs), viewing requirements, materials, functions, etc. driven by the DOME digital thread that connects design information in IBM DOORS, PTC Windchill, and other applications. Figure 8 shows the web interface of the DOME digital twin.

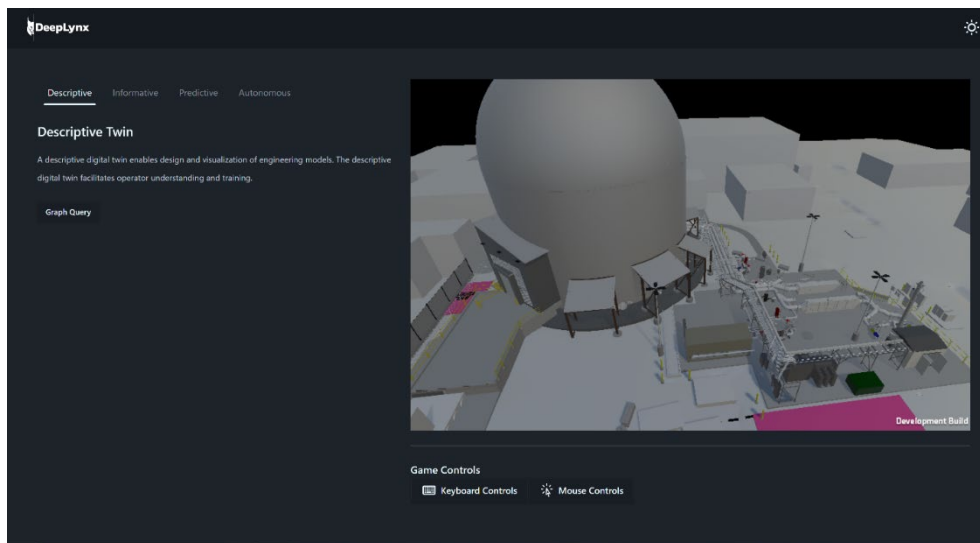


Figure 8: Web browser user interface for the DOME digital twin.

Working ahead of schedule, the Digital Engineering team achieved production deployment of the DOME information digital twin, M2RC-25IN0204033, in September 2025.

## Hardware Integration and Data Streaming

An additional capability was implemented in September 2025 through milestone M3RC-25IN0204034, which established a prototype connection to DOME control system hardware. In anticipation of DOME operations, this milestone developed the software infrastructure to enable data streaming from sensor hardware installed at MFC to the DOME digital twin, allowing remote visualization of DOME measurements.

## Digital Procedure Systems

The Digital Engineering team initiated deployment of a digital procedure system for DOME operations, delivering a PEP ahead of schedule for milestone M3RC-25IN0204036. The project will deploy a procedure system that will enable facility operators to develop and execute operating procedures digitally, improving facility operations efficiency.

## Next Steps

In the upcoming fiscal year, NRIC Digital Engineering will continue progress toward the first nuclear facility digital twin using the DOME. The project will focus on integrating various components including the M&S work being executed at ANL and measurement data streamed from the facility. Once DOME becomes operational and begins recording real-time data, this information will be correlated with simulated facility models using INL-proven machine learning models to deliver insights and predictions to facility operators. Throughout its development, the digital twin will enable collaborator interaction with real test bed information and performance, streamlining future reactor demonstrations.

Concurrently, NRIC Digital Engineering will deploy a digital procedure system for DOME operations enabling facility operators to develop and execute operating procedures more efficiently and effectively.

### 3.6.3 NQA-1 Feasibility Study

Project Start Date:	2024	Work Package Manager:	Chandu Bolsetti
		Work Package Number:	RC-25IN020404

## Objectives

Both NRIC and the nuclear industry have experienced significant challenges from the implementation of NQA requirements. These challenges include capital cost increases, supply chain bottlenecks, often outdated requirements, and the prescriptive nature of the requirements that hinder effective leveraging of advanced reactor technologies' intrinsic safety features.

While NQA is crucial for safety and reliability, questions remain whether the additional stringency offers proportionate benefits. With potential resurgence of nuclear power plant construction in the U.S. and many nuclear developers looking to build their supply chains and workforce, addressing these challenges immediately will have a momentous impact on the nuclear industry. To this end, DOE-NE funded NRIC to conduct a feasibility study on addressing NQA challenges.

The goal of the study is to understand the feasibility of reducing the cost and schedule impacts from NQA by gathering input from all industry stakeholders and then identifying potential solutions to address these challenges. Stakeholders include reactor developers, material and component suppliers, engineering, procurement and construction (EPC) contractors, standards development organizations, regulators (including NRC and DOE), and industry groups including Nuclear Energy Institute (NEI) and Electric Power Research Institute (EPRI).

## Progress and Accomplishments

### Stakeholder Workshop

The NQA-1 feasibility project was completed on July 30, 2025 with the submission of a final project report. A cornerstone of the project was the stakeholder workshop organized in Washington, D.C.,

on December 5-6, 2024. Recognizing the topic's importance to the industry, NRIC partnered with EPRI and NEI, who co-sponsored the workshop titled "NRIC-NEI-EPRI Nuclear Quality Assurance Challenges Workshop."

The fully in-person workshop brought together 85 attendees from 38 organizations with 24 speakers, including reactor developers, suppliers, code committee representatives from American Society of Mechanical Engineers (ASME) NQA-1, ASME Boiler and Pressure Vessel Code (BPVC), American Concrete Institute (ACI) 349, American Institute of Steel Construction (AISC) N690, and American Society of Civil Engineers (ASCE) 4/43, as well as representatives from EPRI, NEI, NRC, and DOE.

Presentation topics included origins and flow of NQA requirements both in NQA-1 and engineering design, challenges implementing these requirements, various industry efforts to address these challenges, and reactor developer perspectives on best practices and improvement opportunities. All workshop presentations were recorded and posted on the NRIC website (<https://nric.inl.gov/event/2024-nqa-workshop/>).

Given the wide spectrum of attendees, the workshop led to new perspectives and dialogue essential to address these challenges. Key workshop themes included:

- Conflating NQA with NQA-1, although NQA requirements originate from several engineering codes and standards such as BPVC and ACI 349, in addition to NQA-1
- Inadequate understanding of the existing flexibility in NQA-1 and 10 CFR Part 50 Appendix B
- Various efforts from the ASME and BPVC code committees to improve the requirements
- Potential risk-informed performance-based (RIPB) methods to reduce requirements
- Need to access the non-nuclear supply chain either through commercial grade dedication (CGD) or the use of commercial quality standards such as International Organization for Standardization (ISO) 9001.

Several follow-on discussions were also held after the workshop.



*Figure 9: NRIC-NEI-EPRI Nuclear Quality Assurance Challenges Workshop.*

## Pathway Development

The project team collected and synthesized stakeholder input to better understand the challenges and identify potential opportunities to address them. The study ultimately identified five potential pathways that encompass addressing cultural issues to cultivate efficient implementation of requirements that already exist (such as the use of CGD to leverage the non-nuclear supply chain), revising requirements in codes and standards where needed, using RIPB approaches to minimize requirements or number of safety-related components, managing requirements through digital tools, developing pathways to meet regulations with commercial quality programs such as ISO-9001, and deploying these pathways in demonstration projects where possible.

Collectively, these pathways provide a comprehensive set of solutions to addressing NQA challenges. Successfully executing these pathways will require a highly collaborative, “Whole-of-Industry” effort. With prime partners NEI and EPRI, NRIC will work closely with all stakeholders including regulators, consultants, standards development organizations, developers, and owners.



Figure 10: Potential pathways to address nuclear quality assurance challenges.

## Impact

If successfully implemented, these pathways will result in significant cost and schedule reductions and accelerate the nuclear power plant deployment, especially advanced reactors. These pathways also help lower barriers between nuclear and non-nuclear supply chains, which not only reduces cost and schedule but also enables much faster innovation—something that is particularly challenging in the nuclear industry.

## Next Steps

NRIC is currently preparing to fund follow-on projects according to the pathways illustrated, contingent on funding availability. Potential projects include:

- Development of technology-agnostic guidance to reclassify some of the civil structures to non-safety related with or without special treatments using RIPB methods

- Performing a thorough review of ACI 349 and AISC N690 (nuclear reinforced concrete and steel construction codes, respectively) to identify requirements that could be removed or revised
- Developing a regulatory pathway for deploying the quality assurance methods that are widely used in safety-related commercial construction (schools, hospitals, chemical facilities, etc.) in nuclear construction.

To enable immediate impact on nuclear construction, NRIC plans to draft topical reports from these studies that, if accepted by NRC, will provide regulatory finality for reactor developers.

### 3.6.4 Advanced Construction Technologies Initiative

Project Start Date: 2022

Work Package Manager:

Luke Voss

Work Package Number:

RC-25IN020405

#### Objectives

NRIC ACTI is a cost-shared public-private partnership supporting transformation in nuclear energy construction and deployment costs, enabling nuclear energy to make important contributions to the energy system of the future. This transformation is critical for increasing the confidence of investors, energy system planners, policymakers and, ultimately, consumers in the capability of nuclear energy to meet future needs. It is therefore a critical element of the advanced nuclear energy system demonstration.

Any development or demonstration project will consider regulatory requirements for commercial nuclear implementation and will incorporate strategies to include regulators in the technology demonstration. ACTI will demonstrate construction technologies that support a cylindrical build such as those used for the BWRX-300 (as shown in Figure 11). The ACTI team is led by GE-Hitachi, with GE-Hitachi funding 40% of design costs and with DOE-NE responsible for the remaining 60%.

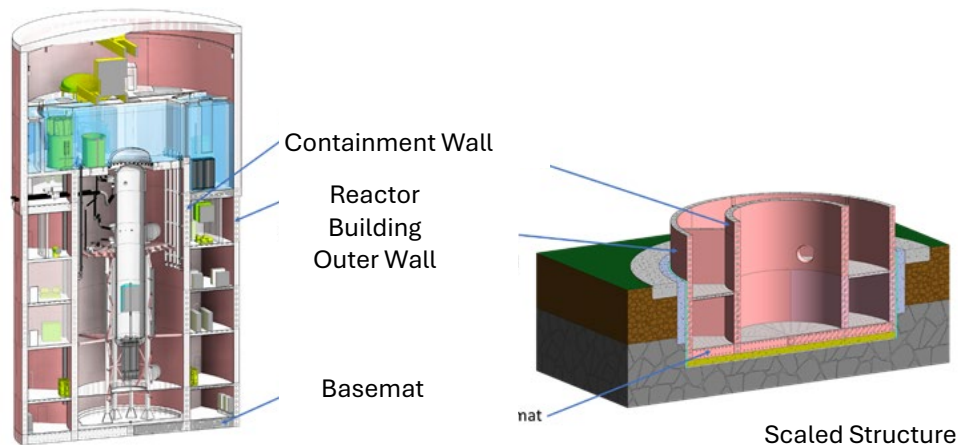


Figure 11. BWRX-300 Reactor Building and ACTI Scaled Structure

ACTI's success is hinged on its collaborations. The design team is composed of universities (Purdue and University of North Carolina – Charlotte [UNCC]), science centers (EPRI and Nuclear Advanced Manufacturing Research Centre [NAMRC]), leaders in nuclear construction (Black and Veatch, Modular Walling Systems Holdings Ltd [MWS], and Cauntion Engineering), and utilities (the Tennessee Valley Authority [TVA], Ontario Power Generation [OPG], and Duke Power). Representatives from both the NRC and Canadian Nuclear Safety Commission (CNSC) have advised the design team. The team is an impressive group of industry leaders focused on advancing new nuclear reactor construction.

The goal of this first cost-shared public-private partnership in ACTI is to demonstrate technologies that, when combined, could reduce the construction costs by more than 10% and significantly lower the associated scheduling risks and uncertainties. These technologies enable parallel work streams, thus condensing the schedules as shown in Figure 12.

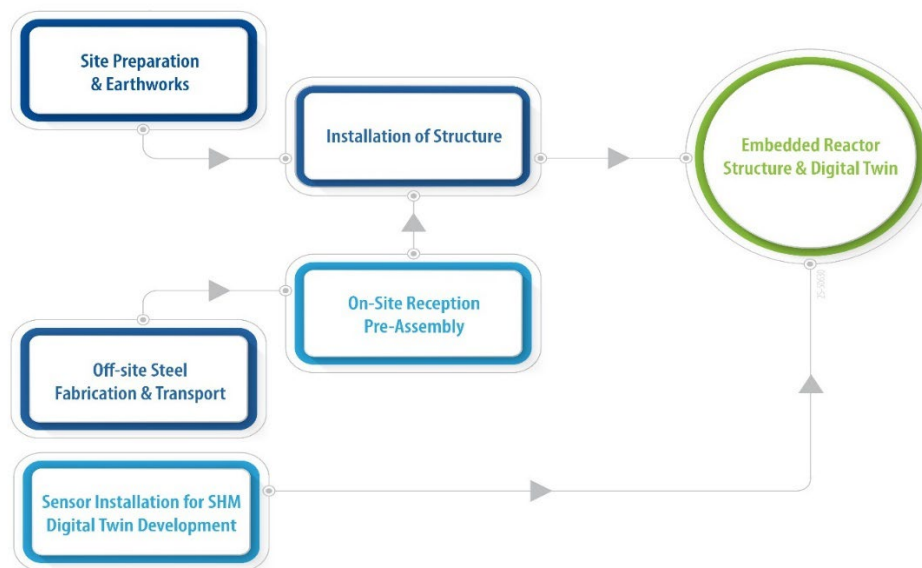


Figure 12: Process Flow Diagram of the Overall Construction and Integration Process

The technologies highlighted by this initiative are as follows:

- **Diaphragm Plate Steel Composite (DPSC):** Next generation steel-concrete composite modules for Seismic Category 1 structures, including containments, with novel techniques to integrate the modules into the basemat, avoiding conventional structural attachment problems. DPSC use will reduce construction time and rework associated with welding rebar in high-strength concrete. The DPSC modules will be shop-fabricated, reducing rework and improving construction quality. Figure 13 shows a diagram of a DPSC module.

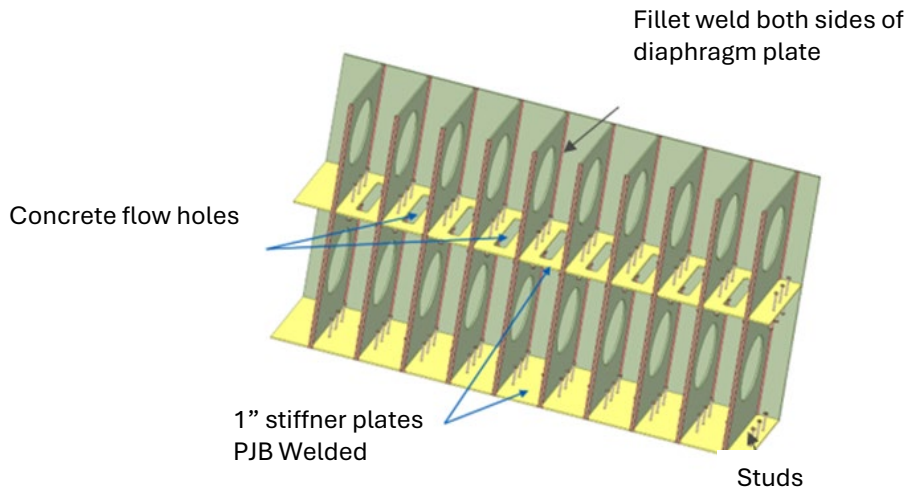


Figure 13. DPSC diagram.

- **Advanced Condition and Performance Monitoring:** Techniques for implementing construction and in-service surveillance programs to address 10 CFR 50.65, “Regulatory Inspection and Monitoring Requirements,” as part of the reliability integrity management plan.
- **Digital Twin:** Digital replica of the structure to integrate sensor data, AI, machine learning, and data analytics.
- **Advanced Reactor Application:** Advanced reactors that could benefit from these technologies include GE-Hitachi’s BWRX-300 and Power Reactor Innovative Small Module (PRISM) reactors, TerraPower’s Traveling Wave Reactor, Molten Chloride Fast Reactor (MCFR), Advanced Reactor Concepts (ARCs’) ARC-100, and DOE’s Versatile Test Reactor.

## Progress and Accomplishments

### Project Phases

The GE-Hitachi ACTI project was divided into two phases. Phase 1 included a detailed, site-specific design of a demonstration reactor containment building utilizing the proposed technologies. Supporting this design, the first phase also included fabrication and testing of steel-concrete composite specimens to validate calculations, models, and assumptions used for containment structure design using steel-concrete composites. Furthermore, Phase 1 included development of an implementation plan for the proposed Phase 2 demonstration as well as identification of nondestructive examination (NDE) techniques deployable on a concrete composite structure during construction.

Upon completion of Phase 1, GE-Hitachi is to propose the demonstration structure design, project cost, and projected construction schedule to NRIC to potentially receive additional funding to move into Phase 2. The second phase (if awarded) would construct a demonstration reactor building structure.

## DPSC Technology Selection and Design

GE-Hitachi chose the DPSC steel-concrete composite design due to several advantages over other steel-concrete composite designs, including reduced weld volume, reduced nondestructive testing (NDT), and simplified fit-up. The DPSC system comprises two continuous plates connected using diaphragm plates. The DPSC diaphragm plate is welded to the face plate using fillet welds designed to develop plate capacity; however, the inspection and welding process (using automated robotic arms) is much easier to achieve than a full penetration weld which is used in other steel-concrete composite designs. The DPSC diaphragm plate and face plate fillet weld inspection is classified as Category H welding and requires only visual inspection.

A DPSC module system consists of multiple components arranged and welded together to form a module, with each component comprising an individual steel element. DPSC modules are spliced together to form structural walls, floors, or mat foundation sections.

## Testing and Validation

GE-Hitachi fabricated several DPSC test specimens sent to Purdue University for structural load testing to validate DPSC performance against computer models and confirm calculations used for analysis and design (see Figure 14). Testing subjected DPSC specimens to various loading scenarios representing accidental pressure and loading conditions, accidental thermal conditions, thermal cycling, and seismic conditions.

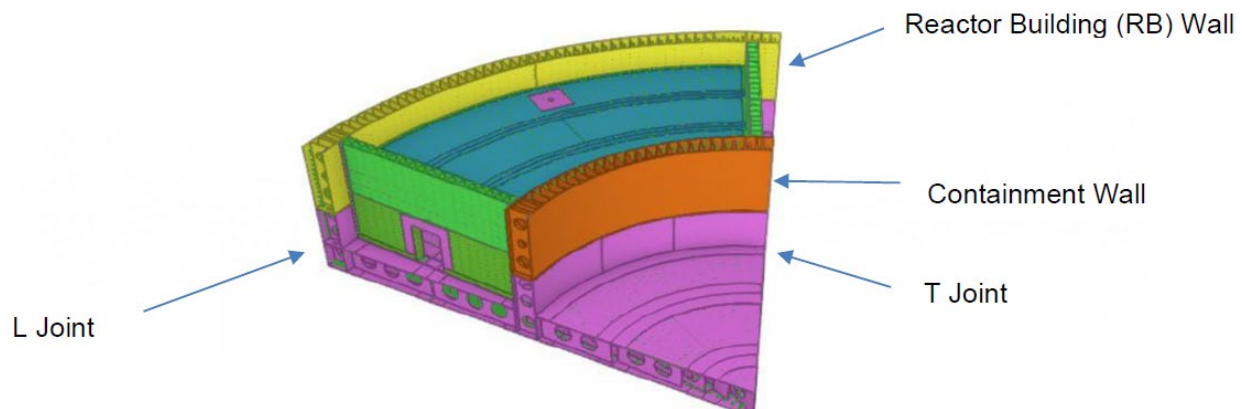


Figure 14. Purdue Testing Rig.

A total of nine DPSC prototype specimens were successfully tested, with all test specimens in all loading conditions meeting or exceeding design criteria. This validated design models, calculations, and assumptions for this construction technology design. Testing helped assess and improve DPSC system constructability and feasibility, as well as welds used in actual construction projects. Testing has also developed relevant experimental results for accelerating regulatory review of reactor building containment designs using the DPSC system.

## Structure Design

GE-Hitachi completed final design of the demonstration structure (see Figure 15) and provided a cost proposal to NRIC for the building and demonstration of this structure using DPSC technology. For the Phase 2 demonstration, due to the funding levels, GE-Hitachi proposed a minimum viable structure that will demonstrate all the key construction techniques, critical connections, concrete application, and various aspects of using DPSC for a cylindrical reactor containment building.



*Figure 15. Digital Representation of DPSC System Demonstration Structure*

With additional funding and extended project timeframe, larger-scale reactor buildings could be built to demonstrate this DPSC technology for an entire facility. The figure shows a digital representation of the proposed minimum viable reactor building structure using a DPSC system with a basemat, containment building wall, outer reactor building wall, critical basemat-to-wall connections, second-level mezzanine, and inner passageway walls.

## Next Steps

Over the past several months, GE-Hitachi and NRIC have engaged in several rounds of proposal feedback and incorporation, as well as finalizing negotiations on the contractual terms and conditions for the Phase 2 project. GE-Hitachi is working to finalize all proposal documents with all feedback incorporated from NRIC.

Once finalized, the Phase 2 proposal will be delivered to NRIC where it will be reviewed and approval by several layers of the INL contracting organization management. Upon INL contracting approval, the proposal will be delivered to local DOE-ID for review and approval. Once approved, the proposal will finally be sent to the DOE-HQ contracting office for final review and approval.

If the proposal is approved and the contract executed, construction activities will then commence on the Phase 2 demonstration structure.

## 3.7 Experimental Infrastructure

### 3.7.1 METL Operations, Testing, Maintenance, and Improvements

Project Start Date: 2020	Work Package Manager: Chris Grandy (ANL)
	Work Package Number: RC-25AN020601

#### Objectives

The Mechanisms Engineering Test Loop (METL) work package includes operations, testing, maintenance of, and improvements to the METL facility and supporting infrastructure that provides a platform for testing innovative systems and components in high-temperature liquid metals. METL is a key facility for fast reactor R&D infrastructure within the U.S and DOE complex. METL operations and testing provide a versatile capability for U.S. industry's liquid metal technology development and fast reactor component testing in a prototypic environment.

This work will include coordination with the Advanced Reactor Technologies (ART) Program Fast Reactor R&D work package as necessary to continue creating a qualification area for METL test assemblies, including ongoing testing of the 28-inch flexicask system and insertion of test articles into METL. The work will also include the development of the improved inductive level sensors for METL. Additional activities may include continuing longevity testing of heaters and wires along with other testing required for METL operations. Resources are utilized by staff to implement and coordinate these efforts. Staff operate and checkout METL equipment, systems, and supporting infrastructure on an ongoing basis.

Operations, testing, maintenance, and improvements to the METL facility support the following objectives:

- Research, develop, and demonstrate advanced innovative technologies that enhance cost reduction and performance for advanced fast reactor applications.
- Develop advanced technologies for accident prevention and mitigation.
- Develop sustained personnel, physical, and knowledge infrastructure for long-term research, development, and demonstration for fast spectrum systems.
- Preserve and nurture the domestic knowledge base and U.S. professional expertise to facilitate science-based R&D.
- Re-establish and maintain U.S. technology leadership for advanced fast reactor technology.

#### Progress and Accomplishments

The METL facility has been operational since September 19, 2018, with funding for its operations from NRIC beginning in April 2022. In FY 2025, METL accomplished the following:

- METL was maintained in a hot molten state 24 hours a day, seven days a week.

- Performed periodic sodium purification runs to maintain sodium purity in METL. During these purification runs, analysis determined that the cold trap was reaching its end of life. The cold trap currently operates at 170°C, but an external customer requires operation at 150°C. When trying to reach 150°C, flow degradation occurs. To address this issue, a new cold trap was procured (identical to installed one), a new and improved cold trap stand was procured, and initiated fabrication of new piping segments for installation.
- Planned and executed the first replacement of the existing cold trap. The new cold trap was procured years ago after METL was first filled with sodium, and the original cold trap was determined to function correctly. After three months of planning, the sodium in the old cold trap was frozen up to the economizer, the old trap was cut out of the piping system, the new cold trap was installed, and the new cold trap was brought on line (see Figure 16 **Error! Reference source not found. Error! Reference source not found. Error! Reference source not found.**). The new cold trap is performing well and has allowed cold trapping to 150°C.
- Supported operations of the Gear Test Assembly (GTA), which completed Test Campaign 9. The GTA seized partway through the Campaign 9 test. Diagnosis identified the issue as a failed air-side drive motors – a replacement motor is being procured.
- Supported operations of the Thermal Hydraulic Experimental Test Article (THETA). In FY 2024, THETA was made fully operational, and in FY 2025, THETA continued its test matrix testing.
- Installed an off-the-shelf structural health monitoring (SHM) system on the piping system for Test Vessel 6. This new system enables monitoring of this piping system and demonstrates high-temperature structural health monitoring systems.
- Prepared a milestone report regarding the installation and testing of a wet vapor nitrogen system to react residual sodium from test articles.
- Supported and completed the installation of Test Vessel 6. This Level 2 milestone work included the installation of piping systems to provide sodium to the test vessel from the main loop and returning sodium to the main loop. Additionally, installation of heaters on the installed piping system was completed. The welds were all radiographed, heat tracing and instrumentation were installed, and the piping and vessel were insulated (see Figure 17 **Error! Reference source not found.**).
- Designed a wet vapor nitrogen system to augment the moist carbon dioxide sodium cleaning system. Currently, test articles removed from a METL test vessel are first reacted for approximately one to two weeks with moist carbon dioxide to convert residual sodium on the test article to sodium bicarbonate. This process does not completely clean test articles. To react additional residual sodium, a wet vapor nitrogen system was installed that enables more sodium to be reacted from a test article before it is removed from the cleaning tank. Components for the wet vapor nitrogen system were procured, installed, and tested. A milestone report was generated for this work.

The METL team presented the status of FY 2025 work at the NRIC Annual Program Review held at the INL on April 1, 2025. In July 2025, the METL team provided facility tours and technology development demonstrations to Secretary of Energy Chris Wright and his delegation (see Figure 18).

The METL Team is collaborating with various Nuclear Energy University Partnership (NEUP) awardees in demonstrating various sensor technologies such as flow monitoring, structural health monitoring, and impurity monitoring. The goal is to deploy all of these sensors at METL once fully developed.



*Figure 16: Test Vessel 6 - Installed*



*Figure 17: New Cold Trap Installed*



Figure 18. Secretary Wright Tours METL

## Next Steps

The METL team will continue to operate, maintain, and improve the facility in support of system and component testing in sodium. The team will support the following:

- Testing of gears and bearings in sodium via the GTA
- THETA testing to support the validation of thermal hydraulic codes
- Preparation for the testing of a vendor test article and a flow sensor test article
- Preparation for testing a full-scale fuel handling gripper mechanism.

### 3.7.2 Molten Salt Thermophysical Examination Capability (MSTEC)

Project Start Date: 2023

Work Package Manager:

Josh Gillespie

Work Package Number:

RC-25AN020602

## Objectives

The deployment of the NRIC MSTEC is crucial for advancing the technical readiness level of molten-salt reactors (MSRs). This will be the only facility in the world offering a comprehensive suite of characterization capabilities for irradiated fuel salts. Characterization of this type of material will significantly advance the deployment of advanced reactors.

The main objective of MSTEC is to support industry partners in the rapid deployment of commercial MSRs (see Figure 19). This capability will provide the infrastructure and equipment to measure the thermal, chemical, and physical properties of both irradiated and unirradiated molten-salt systems. This includes both fuel and coolant salts with prototypical concentrations of actinides, fission products, and corrosion products.

The next generation of MSR designs is largely theoretical. A significant knowledge gap exists regarding the behavior of multicomponent salt systems under reactor conditions and how this behavior changes with fuel burnup and irradiation exposure. It is equally important to understand how physical and mechanical properties of construction materials within an MSR change with temperature, irradiation, and salt exposure. This work directly supports NRIC's mission to demonstrate advanced nuclear energy designs in the near term.

Collecting this data serves two interconnected purposes: (1) to inform accurate design of reactor components, operating procedures, limiting conditions, and predictive models relevant to advanced MSRs, and (2) to enable qualification of MSR fuel and components under NRC licensing requirements. In the long term, the availability of such a capability will allow ongoing monitoring of fuel salt samples taken from irradiation experiments, test reactors, and eventually commercial reactors to validate the important thermophysical properties over their operational lifetimes.

## Progress and Accomplishments

NRIC MSTEC construction continued throughout FY 2025. Significant work efforts included completion of initial leak testing, installation of the eight telemanipulators (milestone M2RC-25IN0206023), installation of in-cell test equipment, installation of the seven feedthrough panels, interconnection of the test equipment to feedthrough panels, installation of all required support equipment, repair of the high-efficiency particulate air filter systems, alteration of furnace well housing, alteration of cooling fan ducting, installation of weld studs throughout the cell interior, final window installation, and the start of acceptance testing.

Additionally, substantial progress was made on radiological work procedures and the development of training material. The NRIC MSTEC Concept of Operations, milestone M3RC-25IN0206022, was issued on July 8, 2025.

As construction concludes in early FY 2026, the project will progress into system testing and validation. This includes acceptance testing of all equipment and components, helium leak testing, radiological source testing of glovebox shielding, and incorporating ventilation flow into the general Fuel Conditioning Facility (FCF) radiological ventilation flow. A formal ribbon cutting ceremony is expected to be held in quarter one of FY 2026. See Figure 19, Figure 20, Figure 21, Figure 22.

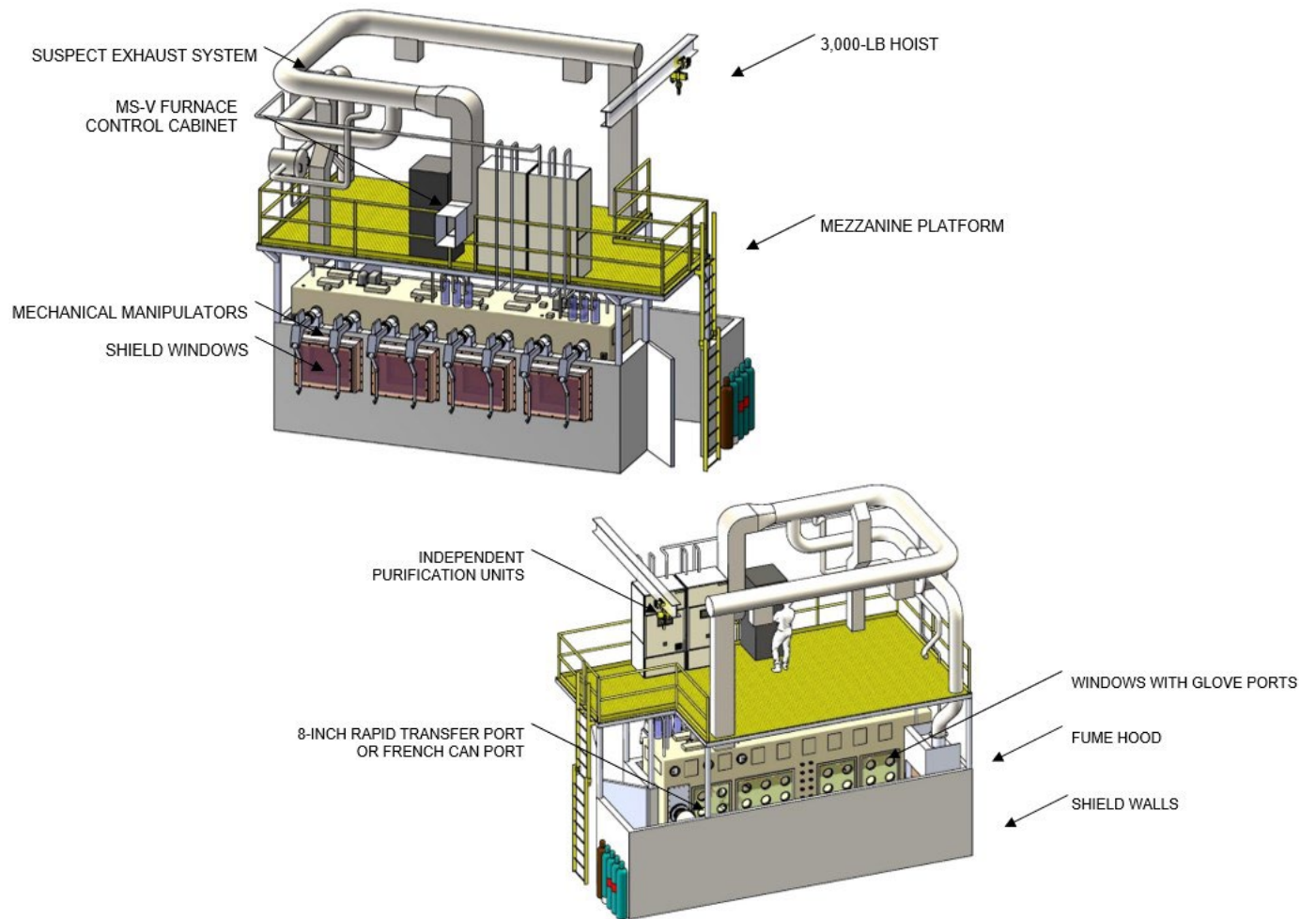


Figure 19. Front and Rear Isometric Views of NRIC-MSTEC

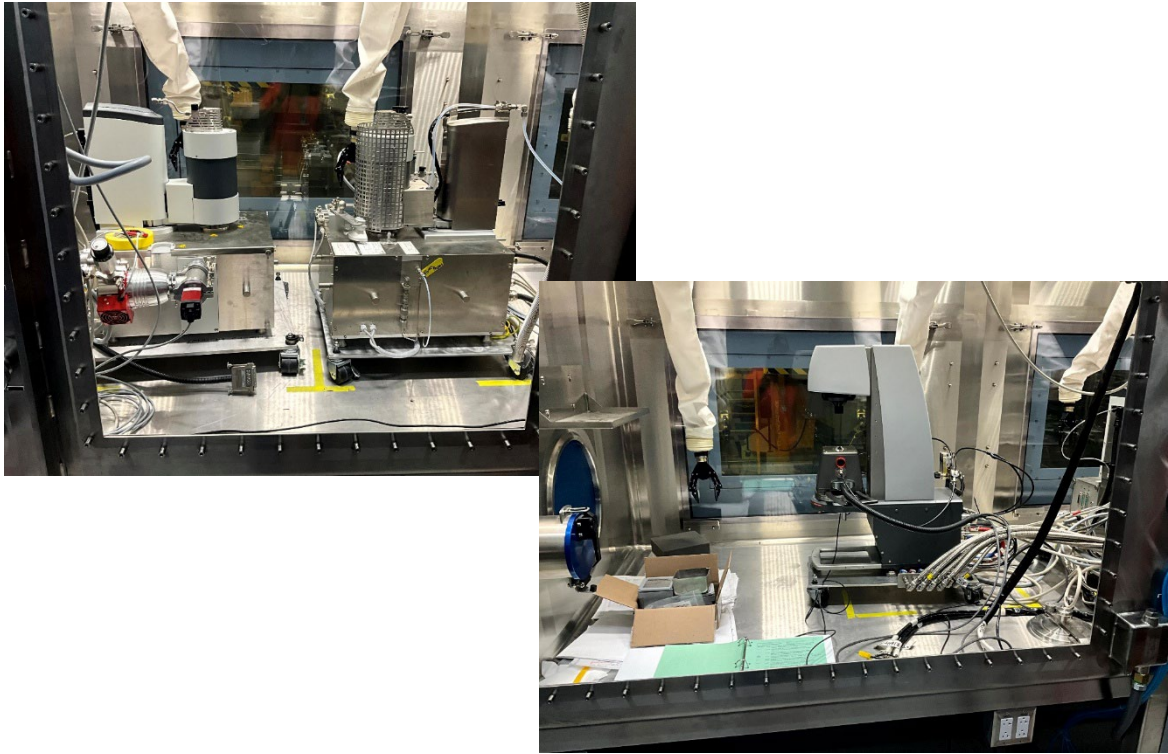


Figure 20. Example NRIC MSTEC in-Cell Test Equipment

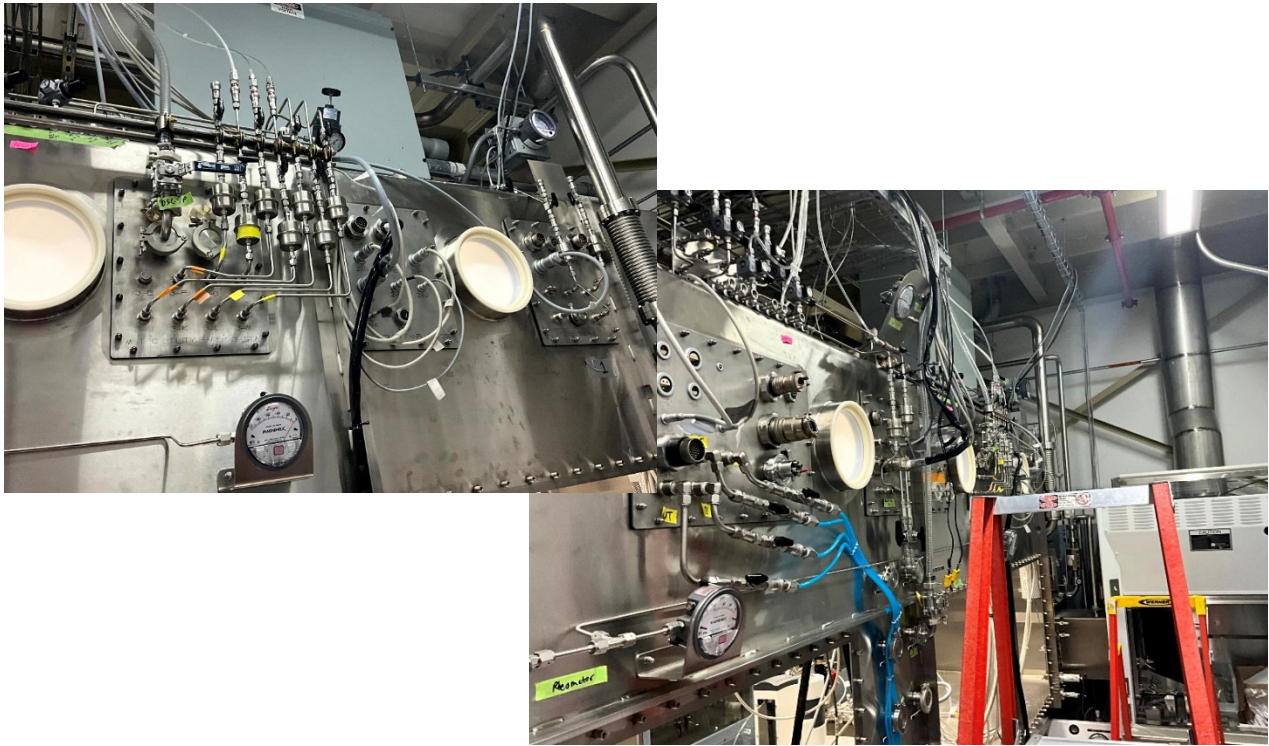


Figure 21. MSTEC Feedthrough Panel Connections



*Figure 22: MSTEC Project Team Testing Telemanipulator Operation*

## Next Steps

In FY 2026, the following NRIC MSTEC activities are scheduled for completion:

- Issuance of NRIC MSTEC operational scheduling documentation
- Call for developers and issuance of production schedule
- Completion of acceptance testing
- Helium leak and radiological source testing
- Training and qualification of personnel
- Operational readiness reviews
- Commencement of MSTEC operations

### 3.7.3 Virtual Test Beds

Project Start Date: 2020	Work Package Manager:	Thomas Folk Lise Charlot
	Work Package Number:	RC-25AN020603 RC-25AN020604

## Objectives

Many advanced reactor concepts under development will require extensive experimentation and analysis campaigns before they are ready for deployment. NRIC is tasked with accelerating the deployment of these designs by providing both physical and virtual infrastructure for testing and development of components. The VTB represents the virtual arm of this effort in that it provides a computational environment for M&S efforts in support of nuclear reactor pilot demonstrations. VTB also supports NEAMS tools used to confirm, verify, and evaluate industry-relevant designs. M&S tools and evaluation methodologies will be a central focus of this project to encourage design review activities. This would support private sector innovators in meeting nuclear technology development needs.

More specifically, the VTB establishes a venue to create simulations of advanced reactor concepts and showcases example use cases. These models have a wide variety of applications, ranging from confirmatory analysis to regulatory safety validation. The project emphasizes the use of advanced, multidimensional, and coupled multi-physics NEAMS codes that are under development at national laboratories. The VTB also coordinates necessary code development and reactor analysis of reactor concepts needed to support potential demonstrations. This effort intends to create non-proprietary, open-source reactor core reference simulations that will be used to promote broader public engagement and validation efforts. These tasks will provide the basis to develop a framework to evaluate design concepts, including a safety review and feasibility assessment. In addition, cross-cutting improvements will be made to NEAMS codes and frameworks, where necessary, for simulating reactors of interest. This effort will provide a starting point to evaluate nuclear demonstration projects, allowing NRIC to be responsive to stakeholder requests.

The VTB work package scope consists of five categories: repository maintenance and upgrades, model development, model hosting, digital engineering support, and stakeholder engagement. Repository maintenance is a continuous process to keep the uploaded models operational and their documentation up to date. Repository improvements are new features added to the GitHub repository and the documentation library hosted on the INL website. Model development activities are conducted by the VTB team when a capability does not exist on the repository and the capability cannot be fulfilled by hosting an existing model. Model hosting activities upload new models to the repository that demonstrate a new code capability, a specific reactor type, or a general unique and novel feature. The VTB provides support to the digital engineering team developing a digital twin of the NRIC-DOME test bed. Stakeholder engagement pertains to activities that promote collaboration.

## Progress and Accomplishments

### Repository Maintenance and Upgrades

- NRIC deployed continuous integration on the INL High Performance Computing (HPC) platform for large transient or high-fidelity computational fluid dynamics (CFD) simulations.
- NRIC launched a registration page to assist in managing the growth in the VTB user base. NRIC will use the registration information to continue to provide top-notch user experience and guide the project to meet the needs of the user base.

### Model Development

- NRIC developed the Sodium-cooled Thermal-spectrum Advanced Research Test Reactor (STARTR) in collaboration with the DOE Microreactor Program to produce public value from DOE investments in the MARVEL program. Neutronics modeling is performed in MCNP and OpenMC, available on the VTB repository.
- NRIC developed an automated workflow to streamline reactor modeling with the DOME shield model and demonstrated the use of a representative DOME reactor based on a generic gas-cooled microreactor design.
- NRIC developed a tool to compute dose rate maps of the DOME facility. This tool will help DOME developers demonstrate that their designs can be operated and tested safely in the DOME facility with regard to radiological protection (see Figure 23).
- NRIC developed a new methodology to improve the thermal modeling of the cavity between the reactor core and shield. This methodology enhances radiation modeling within the cavity, resulting in a more accurate temperature distribution (see Figure 24).

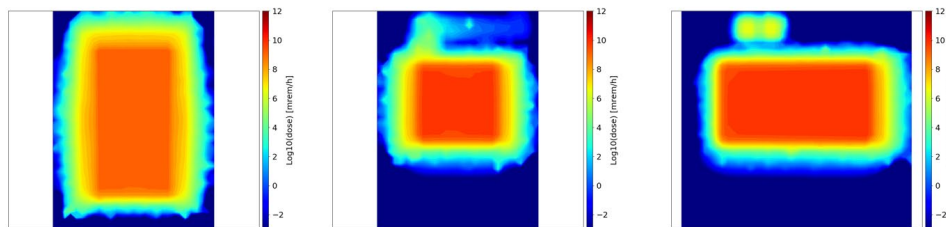


Figure 23: Dose rate maps of DOME with Reactor Supplemental Shielding (XY, XZ and YZ views respectively).

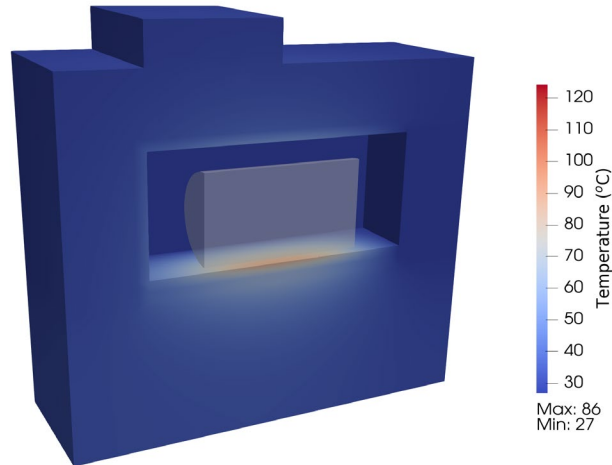


Figure 24: Temperature distribution of the DOME shield using net radiation method with a cylindrical reactor.

### Model Hosting

- The NRIC VTB team, comprised of staff from INL and ANL, added 14 advanced reactor simulation use cases in FY 2025, for a total of 64.

### Digital Engineering Support

- The NRIC VTB team continues to collaborate with the NRIC Digital Engineering team to integrate VTB models with system-level simulations and digital twins.

### Stakeholder Engagement

- NRIC submitted five conference papers for publishing at the American Nuclear Society (ANS) Winter conference where the VTB will, again, host its own special session. NRIC submitted a journal paper highlighting the accomplishments and updates to the VTB.
- NRIC significantly grew the VTB user base, attracting an additional 800 visitors.

### Next Steps

The VTB team strives to maintain the quality and usefulness of the repository and aims to provide that benefit in FY 2026. Additional models of interest will be added to expand the repository, increasing its effectiveness to the advanced reactor development community. In FY 2026, the VTB team plans to increase stakeholder engagement and encourage external contribution to the repository. Furthermore, the VTB team will continue to assist the NRIC Digital Engineering team toward their goals of deploying a digital twin of DOME. Near-term work scope is aimed toward developing a Functional Mockup Unit framework to enable seamless coupling of VTB models with the DOME digital twin.

## 3.8 Integrated Energy Systems and Nonelectric Applications

### 3.8.1 Maritime Applications of Nuclear Energy Studies

Project Start Date: 2020	Work Package Manager: Sanjay Mukhi
	Work Package Number: RC-25AN020701 RC-25AN020702 RC-25AN020703

#### Objectives

Maritime nuclear applications, which represents a potential \$6T market, is a keen focus for several advanced reactor innovators. NRIC has provided a leading role on maritime nuclear issues through the establishment of the Maritime Nuclear Applications Group (MNAG), serving as a resource hub and collaboration platform to aid those in the maritime and nuclear sectors in working towards commercializing these novel deployment opportunities. MNAG hosts quarterly meetings and working groups that drive progress on R&D, regulatory, finance, and public acceptance of maritime nuclear by pulling together industry insights from multiple sectors. MNAG, which grew to nearly 200 members in FY 2025, has a growing interest in floating nuclear power, power for offshore oil and gas operations, and nuclear propulsion for commercial applications. NRIC's activities are designed to raise awareness, foster collaboration, and identify paths forward to enable commercial maritime use of nuclear energy.

#### Progress and Accomplishments

From July 2024 to July 2025, the following was accomplished:

- MNAG led integration of industry insights and NRC feedback to finalize a foundational document that catalyzes the maritime nuclear regulatory landscape.
- MNAG developed economic models that highlight the value of deploying maritime nuclear reactors while also addressing public acceptance issues that the maritime nuclear community needs to address.
- NRIC finalized four deliverables with the ABS under funding announcement DOE FOA ARD-21-26386, "Accelerating Commercial Maritime Demonstration Projects for Advanced Nuclear Reactor Technologies." This industry funding award lays the framework for addressing challenges in the maritime domain so that new reactor technology can be deployed rapidly to transform the maritime industry and create market disruption that will provide unique competitive advantages for U.S. companies that design, build, operate, and support maritime assets.
- NRIC held quarterly MNAG meetings that addressed progress on maritime nuclear issues within universities, amongst regulators, classification societies, as well as highlighted issues related to liability, security, and safety of maritime nuclear applications.

- MNAG published monthly newsletters for MNAG members that highlighted updates of maritime nuclear issues globally.
- NRIC cohosted a workshop with the ABS in October 2024 in Houston, Texas for stakeholders in the nuclear, maritime, and oil and gas industries to examine testing requirements for nuclear-powered offshore oil & gas applications. The workshop brought together 60 participants and helped forge oil & gas majors' interest in establishing a JIP to minimize risk to advanced nuclear reactor research for the oil & gas industry.
- NRIC participated in the International Atomic Energy Agency (IAEA) 24th INPRO Dialogue Forum, which focused on Floating Nuclear Power Plants (FNPPs).
- NRIC provided support to DOE-NE related to interagency meetings, background materials for engagements with innovators, and facilitated new engagements with maritime regulators.
- NRIC participated in February 2025 FNPP Interagency Workshop in Washington, DC.

## Next Steps

MNAG will develop an in-depth examination of the suitability of advanced reactor technology types with maritime applications and vessel types. This effort will result in technical insights, performance criteria, and compatibility assessments to guide stakeholders in selecting the most appropriate advanced reactor technologies for specific maritime use cases.

MNAG will develop an integrated project management framework that incorporates the timeline and regulatory process of a nuclear project with an offshore O&G project. Developing this stage-gate framework will aid potential first-movers from the O&G industry with decision-making about executing maritime nuclear applications.

MNAG will develop siting considerations for FNPPs. The effort will investigate deployment considerations for domestic siting of an FNPP and associated regulatory considerations. Clarifying the uncertainty regarding siting requirements for FNPPs will instill greater confidence among reactor developers and the maritime industry with the prospects of future deployments.

MNAG will conduct a port modernization study that evaluates the feasibility of deploying nuclear generation at or near ports through case studies including small, medium, and large ports in a range of locations (dense urban versus less populated). Given that the easiest path to support the maritime industry with nuclear energy is through providing reactor power to ports, this project will aid in developing a pathway for enabling early integration of commercial nuclear energy to support the maritime industry.

MNAG will establish a language guide of accepted terms across the maritime and nuclear sectors that can be used for understanding multidisciplinary issues. There are many similar or related terms with different meanings and developing a robust glossary will aid both industries in communicating across multidisciplinary technical projects.

MNAG will conduct two working group meetings focused on seeking input to what Safety, Security, Safeguards and Liability (3S+L) looks like for maritime applications for nuclear. The first working group would focus on input from industry and academia, with the second working group focused on a discussion within the U.S. interagency. From these working group sessions, a lessons learned document will be compiled. This effort will address a critical barrier to entry from the U.S.

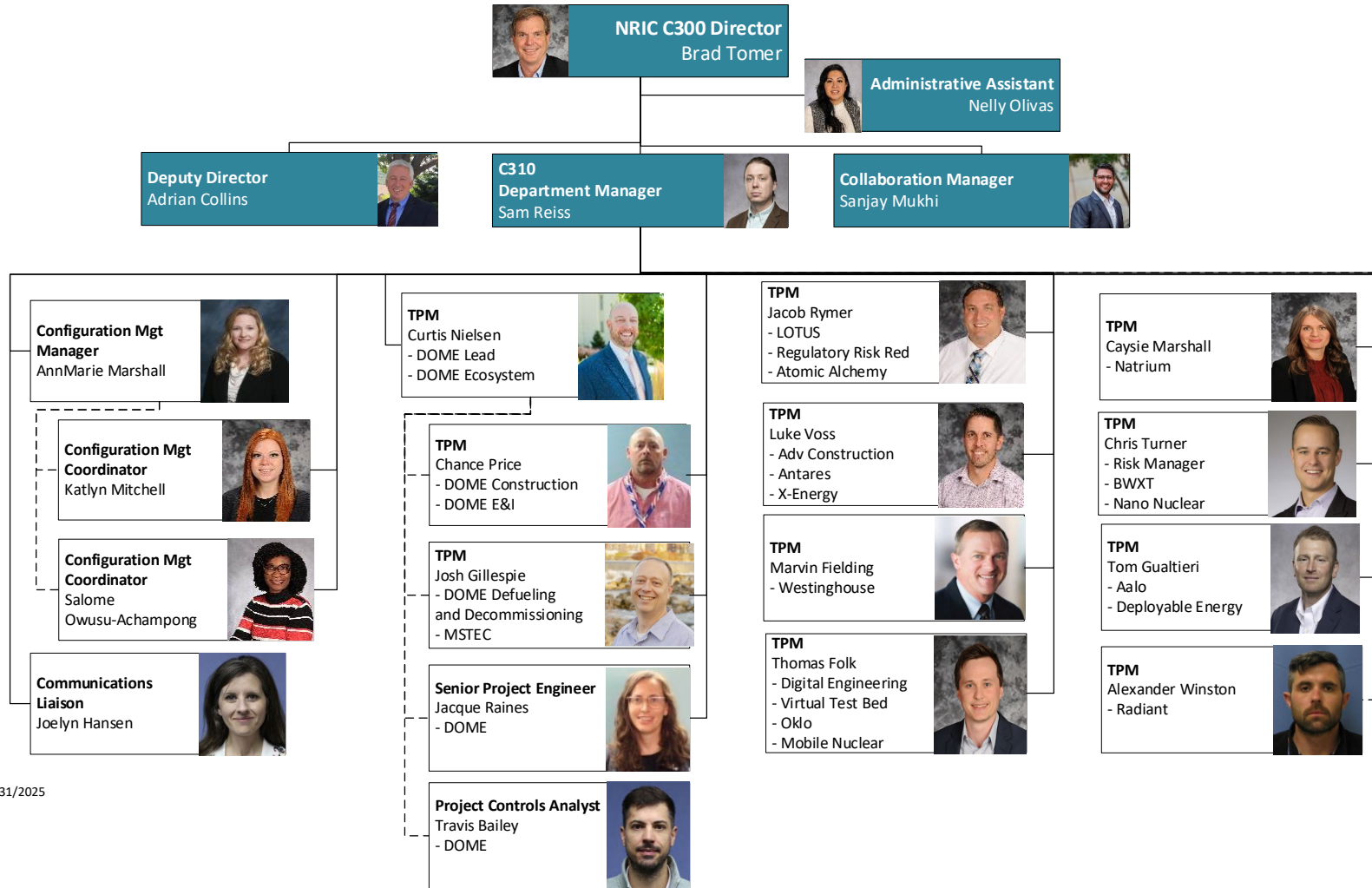
Interagency and the maritime nuclear industry, which is essential to understand the potential implications for international deployments.

MNAG will leverage MOOSE, which is an INL-developed physics M&S platform that can simulate nuclear reactors (core physics), to simulate maritime environments (e.g., displacements and vibrations from ocean waves and wind forces). These numerical simulations in MOOSE can unpack the complex physics involved in reactor cores subjected to maritime environments and shed some light on the physical phenomena that are important to safety. Insights from these numerical simulations can then be used to select and prioritize larger, more investment-intensive, laboratory experiments that might be needed for regulatory approval.

NRIC will continue to support DOE-NE on maritime nuclear-related topics as needed.

## Appendix A

### NRIC Organization Chart



Rev 1 – 07/31/2025