NRIC National Reactor Innovation Center

National Reactor Innovation Center

Program Review

Welcome

Partnering with industry to deploy advanced nuclear at the speed of a startup

Unleashing Golden Era of American Energy Dominance

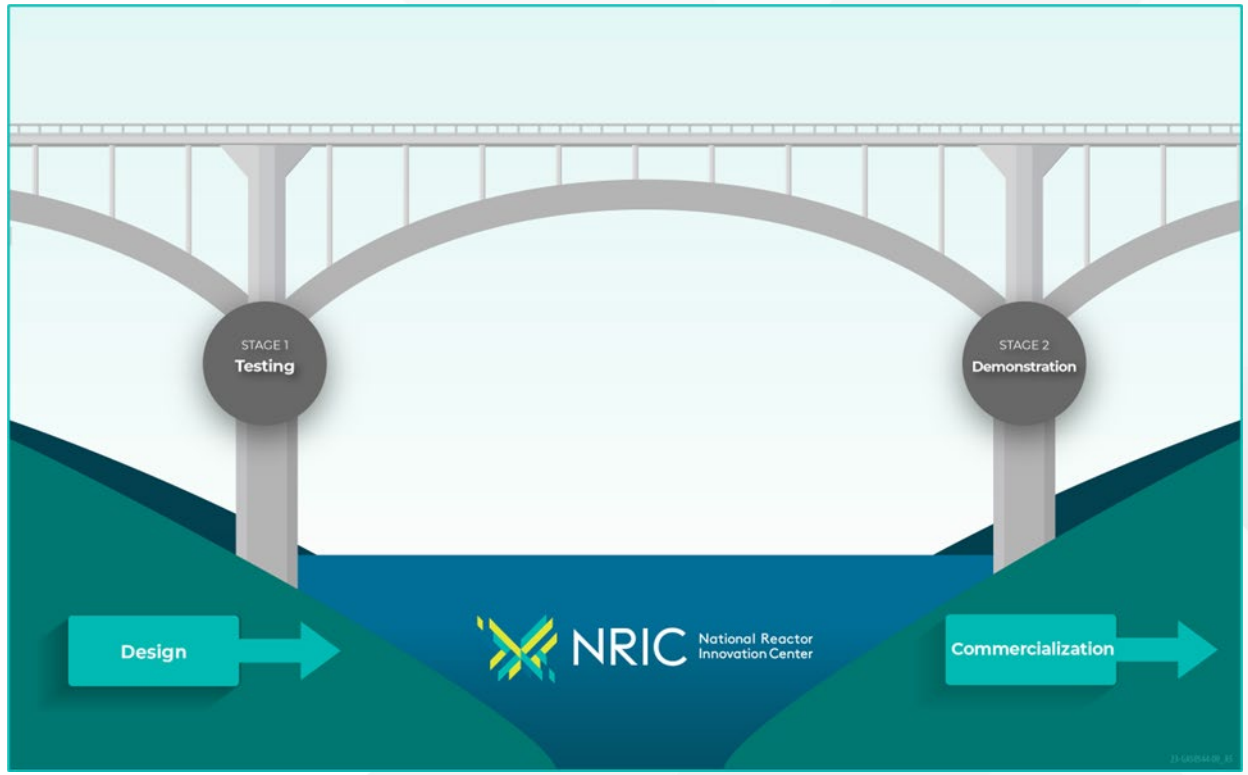
- Memo from Chris Wright, Sec of Energy, Feb 5, 2025
- Bold and ambitious agenda to expand energy & reduce costs
- Unleash American Energy Innovation:

The Department's Research and Development (R&D) enterprise is the envy of the world. We must focus our time and resources on technologies that will advance basic science, grow America's scientific leadership, reduce costs for American families, strengthen the reliability of our energy system, and bolster America's manufacturing competitiveness and supply chain security. As such, the Department's R&D efforts will **prioritize the commercialization of affordable and abundant nuclear energy**. As such, the Department will work diligently and creatively to **enable the rapid deployment and export of next-generation nuclear technology.**

The National Reactor Innovation Center (NRIC) is a DOE program launched in FY 2020

NRIC Enables Nuclear Reactor Tests & Demonstrations

- Authorized by the Nuclear Energy Innovation Capabilities Act (NEICA)
  - Department of Energy (DOE)-Office of Nuclear Energy; INL Nuclear Science & Technology
- Partner with industry to bridge the gap between research and commercial deployment
- Leverage national lab expertise and infrastructure



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Deputy Assistant Secretary for Nuclear Reactors, NE-5

NE-5 27H 000 0000

DAS for Nuclear Reactors

Rian Bahran, Deputy Assistant Secretary
Florence Knauf, Associate Deputy Assistant Secretary
➢ Erica Davenport, Support Service Contractor

NE-51 27H 100 0000
Office of Reactor Sustainability

C. Bunting, Director

S. Goetz, Physical Scientist
J. Marcinkoski, General Engineer
D. Warner, General Engineer

NE-52 27H 200 0000
Office of Advanced Reactors

A. Hahn, Director

Advanced Reactor Technologies Team

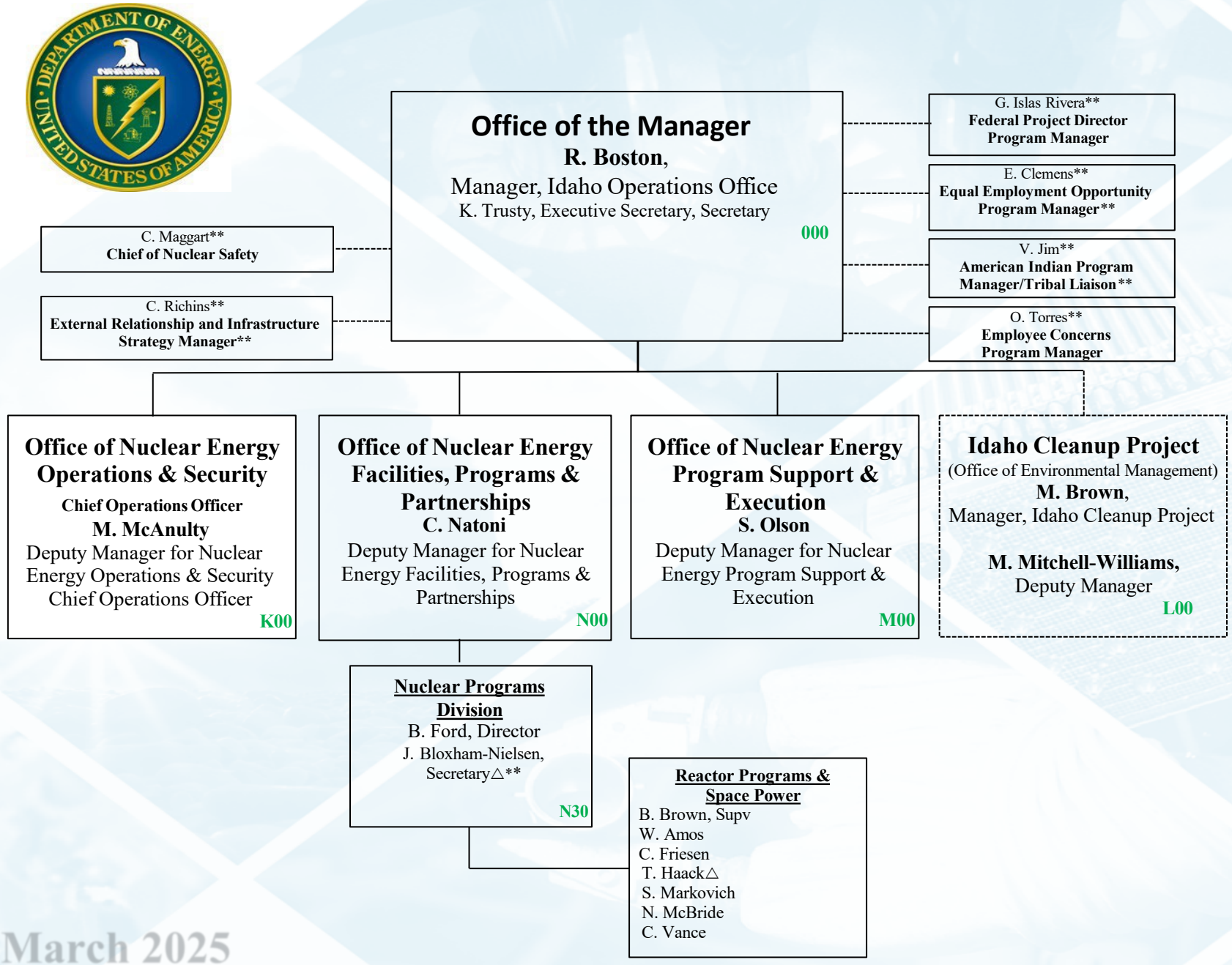
J. Eddins, Team Leader
M. Hahn, General Engineer
K. Abbott, General Engineer

Advanced Reactor Applications Team

O. Tabatabai, Team Leader
M. Bates, General Engineer
S. Fitzwater, General Engineer
D. Li, Nuclear Engineer

(DR) Deferred Resignation Program
➢ Non-Federal Staff

Fed FTEs: 15
Support/M&O: 1


Office of the Manager
R. Boston,
Manager, Idaho Operations Office
K. Trusty, Executive Secretary, Secretary
000
C. Maggart**
Chief of Nuclear Safety
C. Richins**
External Relationship and Infrastructure Strategy Manager**
G. Islas Rivera**
Federal Project Director
Program Manager
E. Clemens**
Equal Employment Opportunity Program Manager**
V. Jim**
American Indian Program Manager/Tribal Liaison**
O. Torres**
Employee Concerns Program Manager
Office of Nuclear Energy Operations & Security
Chief Operations Officer
M. McAnulty
Deputy Manager for Nuclear Energy Operations & Security
Chief Operations Officer
K00
Office of Nuclear Energy Facilities, Programs & Partnerships
C. Natoni
Deputy Manager for Nuclear Energy Facilities, Programs & Partnerships
N00
Office of Nuclear Energy Program Support & Execution
S. Olson
Deputy Manager for Nuclear Energy Program Support & Execution
M00
Idaho Cleanup Project
(Office of Environmental Management)
M. Brown,
Manager, Idaho Cleanup Project
M. Mitchell-Williams,
Deputy Manager
L00
Nuclear Programs Division
B. Ford, Director
J. Bloxham-Nielsen, Secretary△**
N30
Reactor Programs & Space Power
B. Brown, Supv
W. Amos
C. Friesen
T. Haack△
S. Markovich
N. McBride
C. Vance

March 2025

National Reactor Innovation Center

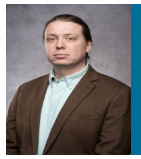
Director
Brad Tomer

Administrative Assistant
Nelly Olivas

Deputy Director/ Chief Program Officer
Adrian Collins

Collaboration Manager
Sanjay Mukhi

Demonstration Infrastructure and Support/Demonstration Project Partnerships – C310



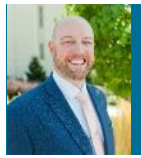
Department Manager
Samuel Reiss

Technical Program Manager
Chance Price

Technical Program Manager
Thomas Folk

Configuration Mgt Coordinator
Salome M. Owusu-Achampong

Configuration Control Manager
AnnMarie Marshall



Technical Program Manager
Curtis Nielsen

Technical Program Manager
Caysie Marshall

Configuration Mgt and Risk Mgt Coordinator
Katlyn Mitchell

Technical Program Manager
MW Patterson

Technical Program Manager
Jacob Rymer

Technical Program Manager
Christopher Turner

Technical Program Manager
3 Vacant

Technical Program Manager
Luke Voss

Technical Program Manager
Marvin Fielding

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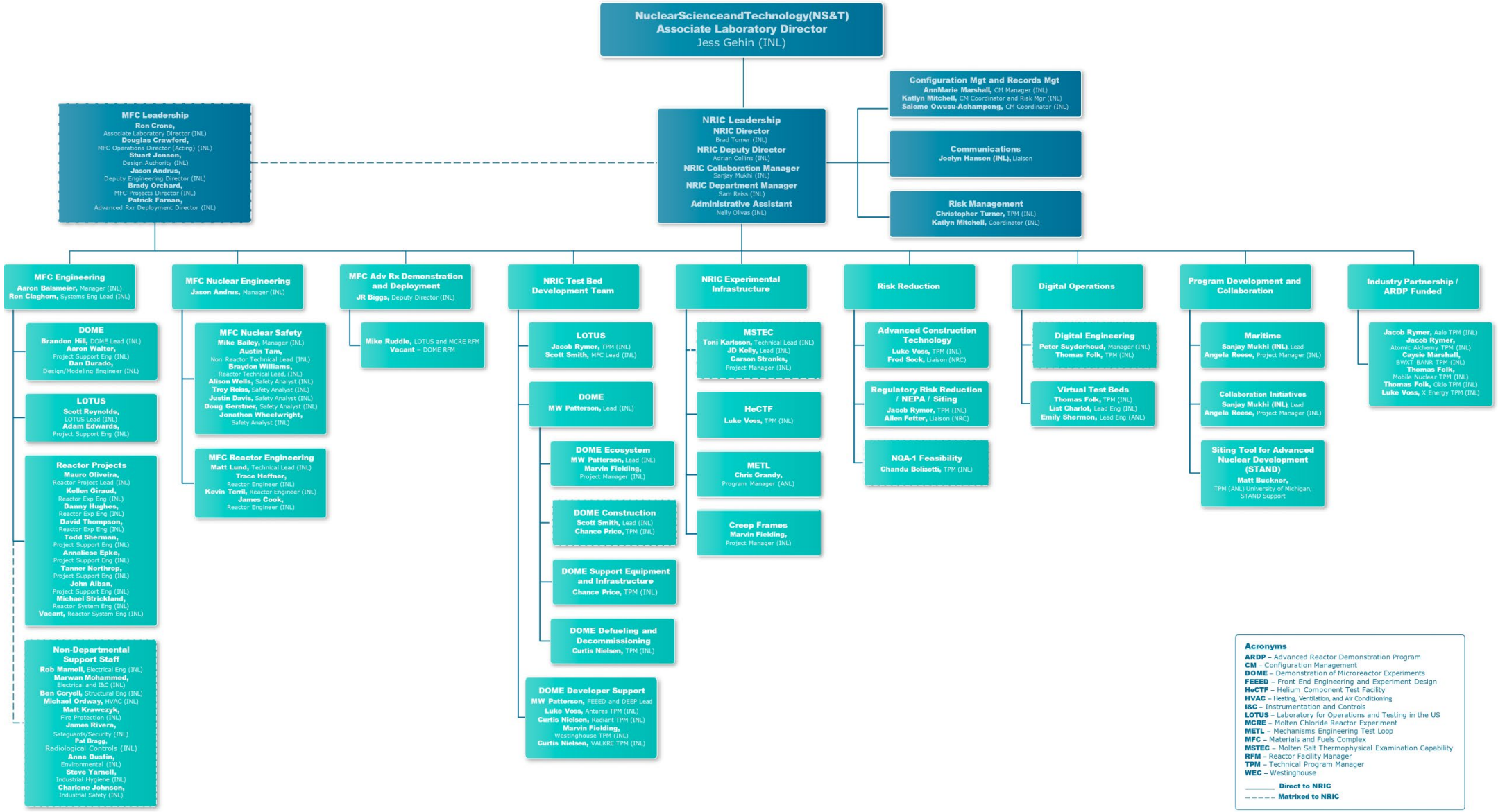
NRIC EXPANDED ORGANIZATION CHART



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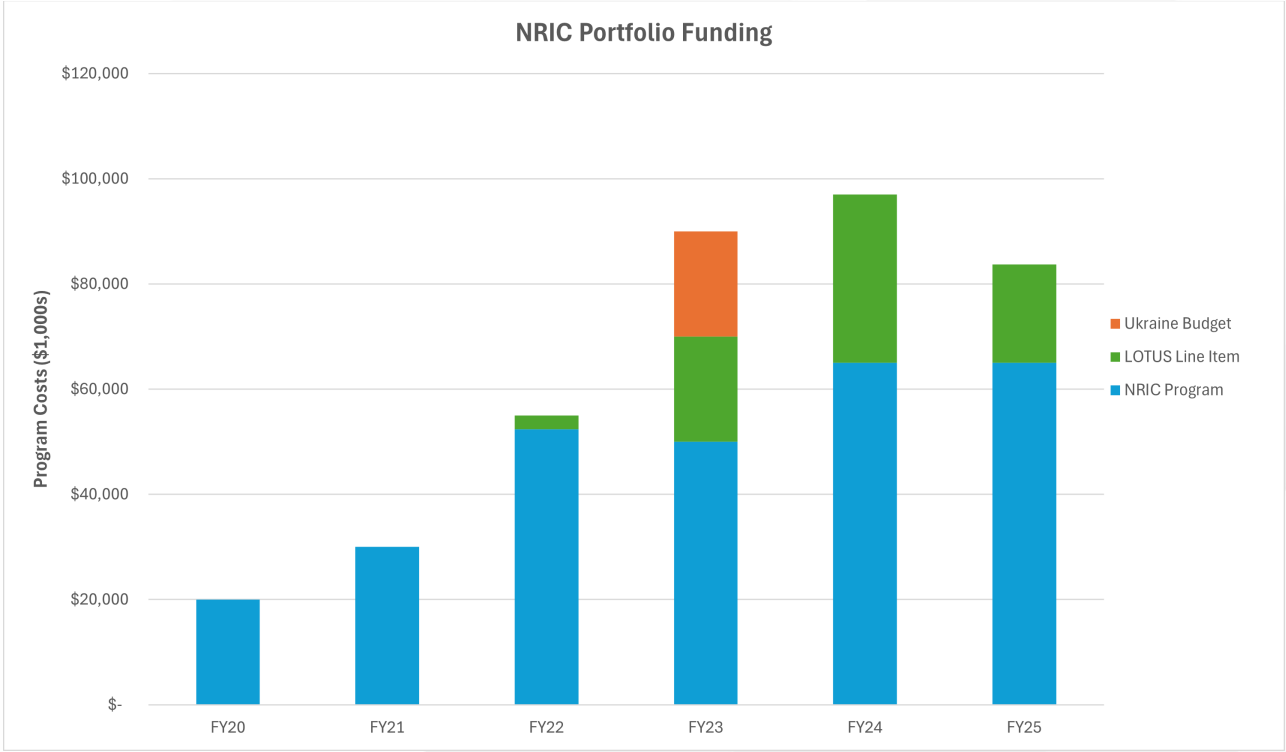
NRIC Portfolio Budget (FY20-FY25)

- FY20 $20M NRIC Program
- FY21 $30M NRIC Program
- FY22 $55M : NRIC Program $52.4M, LOTUS Line Item $2.6M
- FY23 $90M: NRIC Program $50M, LOTUS Line Item $20M, Ukraine $20M
- FY24 $97M: NRIC Program $65M, LOTUS Line Item $32M
- FY25 $83.7M: NRIC Program $65M, LOTUS Line Item $18.7M



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Portfolio Built to Empower Innovators

- **Advancing Reactor Testing**
  - Advanced Reactor Test Beds
  - Experimental Facilities
  - Virtual Test Bed

- **Addressing Costs & Markets**
  - Advanced Construction
  - Digital Engineering for Nuclear
  - Maritime Applications

NRIC-DOME Test Bed Ecosystem

Test bed ecosystem extends beyond facility construction:

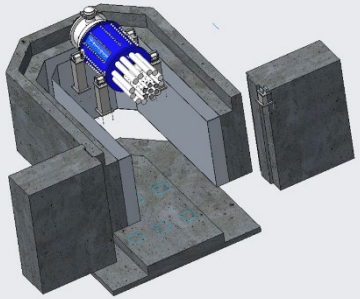
- Complete end-to-end support from fresh fuel storage, supplemental shielding, testing support, and decommissioning
- Processes and procedures to ensure consistent, repeatable testing

Rapidly preparing for testing in NRIC-DOME:

- Four developers in various stages of engineering and experiment design
- Envelop environmental assessment drafted awaiting DOE approval

Committed to optimizing the use of the NRIC-DOME for testing:

- Evaluating options to fuel and assemble reactors outside of NRIC-DOME and other options to maximize use of NRIC-DOME by minimizing time needed in NRIC-DOME.



NRIC-LOTUS Test Bed

Accomplishments:

- Completed Final Design and submitted Preliminary Documented Safety Analysis to Department of Energy-Idaho (DOE-ID.)
- Received Construction Proposals
- CD-3A, Long-Lead Procurement Authority received

Next Steps:

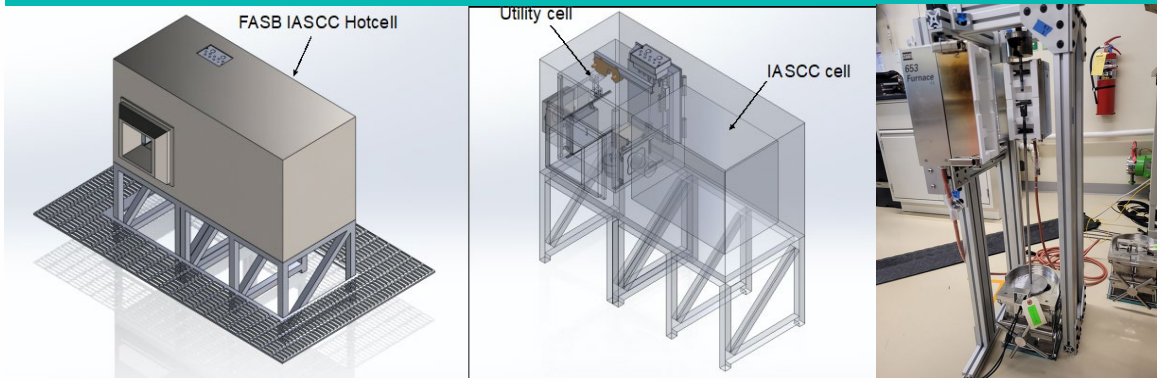
- Submit CD3/3B documentation
- Award construction contract

First Reactor Test:

- Molten Chloride Reactor Experiment
- Southern Company & Terra Power
- Funded through DOE Advanced Reactor Demonstration Program – Risk Reduction

NRIC Experimental Infrastructure

In-HotCell Thermal Creep Frame [2025]



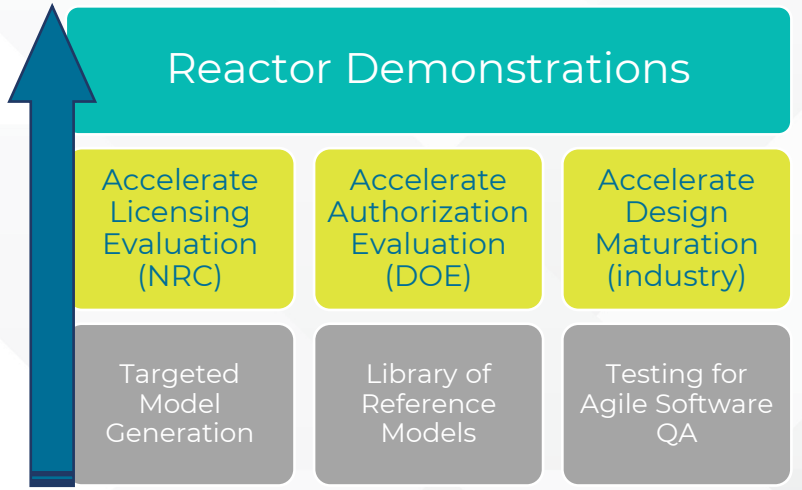
Mechanisms Engineering Test Lab (METL) [Operating since 2018]

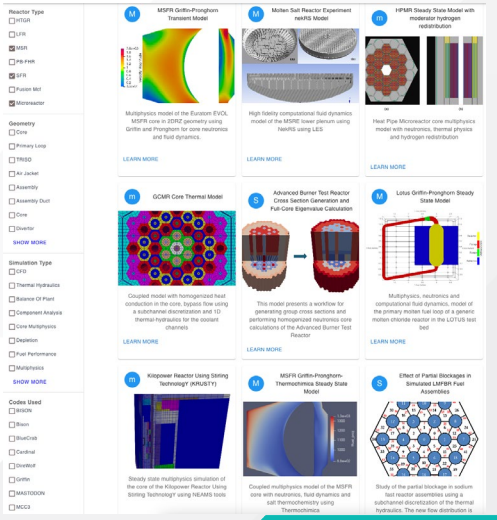
Molten Salt Thermophysical Examination Capabilities (MSTEC) [2025]

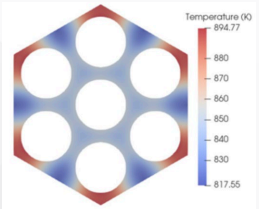
Helium Component Test Facility [2022]

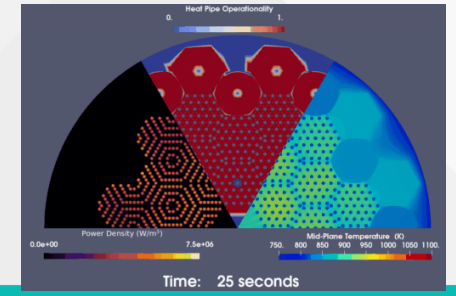
NRIC – Virtual Test Bed (VTB)

- Central location for reactor developers/stakeholders to access and leverage state-of-the art ModSim models of advanced reactors to evaluate performance and safety.
- Cross-laboratory and cross-program collaboration between NRIC and DOE Nuclear Energy Advanced Modeling and Simulation (NEAMS) program.
- Repository/library of simulations for liquid metals, gas cooled, molten salt and micro reactors (continuously tested).
- Currently hosting 60+ distinct models with 15 NEAMS codes with a user-friendly search engine.
- Averaging 280+ visits/month
- Nuclear Regulatory Commission is a strong user/supporter of the Virtual Test Bed for training their staff and developing cases for proprietary designs.









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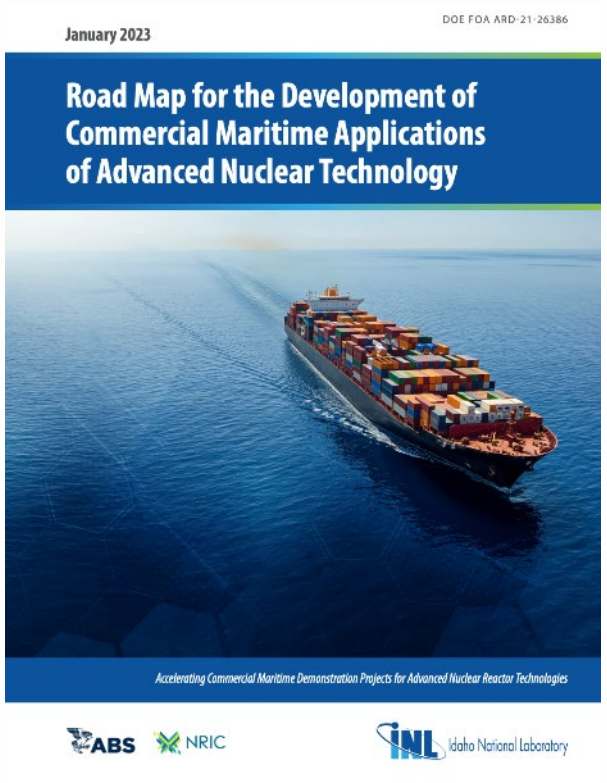
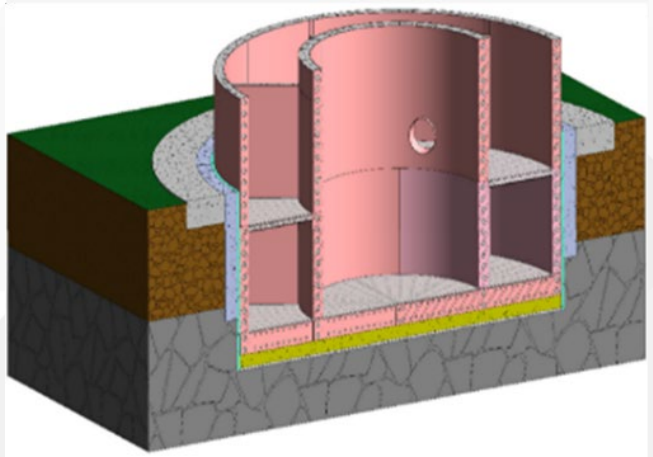
Addressing Cost and Markets

- Advanced Construction Technologies
- Digital Engineering & Knowledge Sharing/Lessons Learned
- Demonstration/Deployment Opportunities (Maritime)





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Advanced Construction Technologies

Demonstrate Technologies:

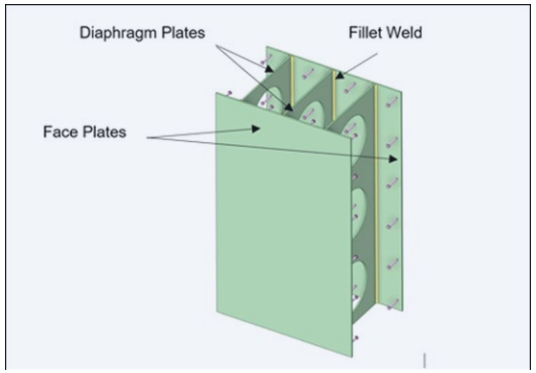
- Significantly reduce cost of new Small Modular Reactors (SMR) builds
- Compress construction schedule by as much as 25%
- Reduce required site work & improve overall quality of structure
- Support long-term structure monitoring

Phase One Recent Accomplishments:

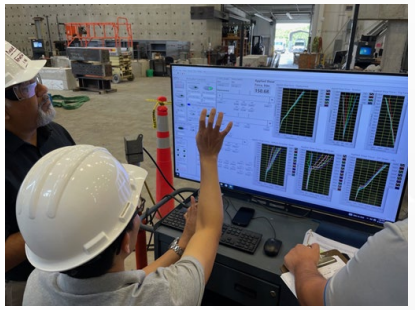
- PARI DPSC testing complete & successful 11/18/24

Optional Phase Two:

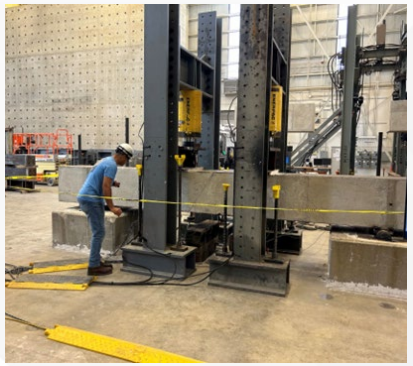
- Demonstrate 60-degree pie shape containment walling system
- Inner and outer walls, base mat integration, multi-story
- Deploy digital twin plus sensor technology for monitoring
- NDE Execution and Deployment
- NRC Engagement & Decommissioning



Diaphragm Plate Steel Composite (DPSC)

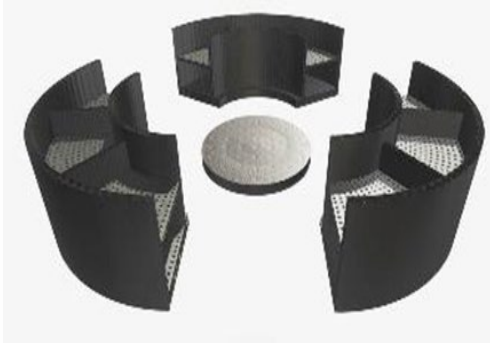


Testing DPSC samples at Purdue



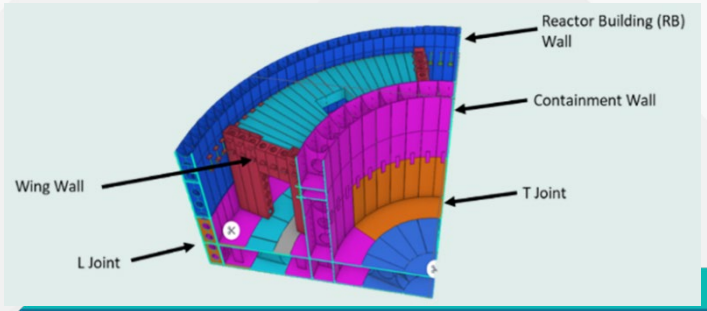
Team – General Electric Hitachi

EPRI, Black & Veatch, Purdue Applied Research Institute, UNCC, Aecon, and Tennessee Valley Authority



Modular Wall Concept

Proposed Phase II containment system



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Nuclear Quality Assurance Challenges Feasibility Study

- Initiated feasibility study to address nuclear quality assurance challenges
  - Economics studies have shown significant cost escalation associated with nuclear quality assurance standards (10 CFR Part 50 Appx B and ASME NQA-1)
  - Due to lack of recent activity, nuclear-certified suppliers are sparse, causing supply-chain bottlenecks (and further cost escalation)
- Nuclear Quality Assurance Challenges Workshop held on Dec 5 and 6, 2024 in Washington, D.C.
  - More than 80 attendees including 24 speakers from 38 organizations
  - Stakeholders included reactor developers, EPCs, material and component suppliers, code committee representatives (ASME NQA-1, mechanical and civil/structural design codes), NRC, DOE, EPRI, and NEI
  - Discussed the origins of QA requirements, best practices and misconceptions, challenges, and potential solutions
- Very encouraging results

NRIC

NEI NUCLEAR ENERGY INSTITUTE

EPRI ELECTRIC POWER RESEARCH INSTITUTE

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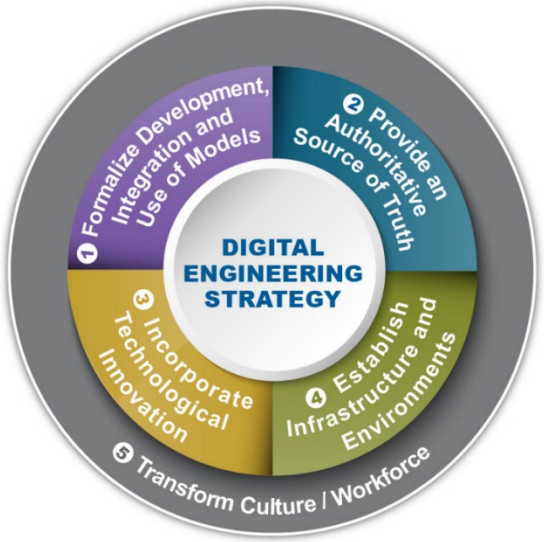
Digital Engineering (DE)



- **What?** An integrated digital approach that uses authoritative sources of truth for data and models across disciplines to support project lifecycle activities from concept through disposal.
- **Why?** With typical industry project **cost overruns** of 241% and 180% in **schedule delay**, digitization of the overall processes can have a significant impact on nuclear deployment and cost viability.
- **Implementation Process & Progress to Date**
  1. Transform the way organizations generate design data by deploying **model-based tools**: IBM DOORS Next, Innoslate MBSE, PTC Creo, Autodesk Revit, etc. [Complete, TRL 9]
  2. Transform the way organizations manage, store, and connect data using **digital threads** to form a comprehensive **digital ecosystem**: PTC Windchill, INL Deep Lynx Warehouse, software adapters & APIs, etc. [In Process, TRL 6]
  3. Transform the way organizations leverage data using **digital twin** technology: extended reality (XR), Unity game engine, real-time data acquisition (DAQ), machine learning (ML), artificial intelligence (AI) [In Process, TRL 3]
- **Next Steps**:
  - Progress digital ecosystem development and release “playbook” and open-source code repository.
  - Develop first nuclear facility digital twin at DOME incorporating physics-based modeling, predictive machine learning, real-time data feedback, etc.

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Integrating AI to the DOE Authorization Process

FY24: Developed Architecture for Leveraging Digital Tools:

- Mapped semi-autonomous DOE Authorization Documents
  - NRIC digital engineering tools: DOORS, DeepLynx, Windchill.
  - Single source of truth using the digital thread
  - AI large language models for document creation
  - Graphical user interface (GUI) to accelerate reviews

FY25: Pilot project demonstration:

- Enhanced digital thread for Artificial Intelligence (AI) integration
- Pilot project is High Temperature Gas Reactor (HTGR) in NRIC-DOME
  - Create input documents - Aug 2025
  - AI generated nuclear safety document – Dec 2025

Challenges:

- Government cloud limits AI capabilities; Investigating opportunities

Impacts:

- 30-50% decrease in time to develop and review safety documents
- Accelerated authorization reviews to support rapid authorization of test bed experiments
- Future application to Nuclear Regulatory Commission (NRC) reviews to accelerate deployment

Evaluating Maritime Applications NRIC & American Bureau of Shipping (ABS)

Maritime Nuclear Application Group:

- Collaboration with ABS and Morgan & Lewis Law Firm
- Research Hub and Resource Center
- 175 members representing 80+ companies
- Gap assessment of testing capabilities for maritime nuclear applications
- Future work to examine 3S+L for maritime applications and develop MACCS codes to assess environmental impacts caused by sabotage or acts of terrorism

ABS iFOA Award:

- Business cases and demo pathway (Task 1)
- Configuration models of advanced reactors integrated with maritime applications (Task 2)
- DOE Testing Readiness Report (Task 3)
- Upcoming: Overcoming Challenges to Nuclear-Maritime Demonstrations (Task 4)

*MNAG is a **research hub** and **resource center** that brings together experts from the maritime and nuclear energy sectors to facilitate the demonstration of advanced nuclear technologies for a range of marine applications.*

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2025 Gap Assessment Update

- NRIC is a continuous learning, agile organization
- 2025 Update to 2020 Gap Assessment
  - Engaged reactor developers, DOE-NE, National Labs, and industry Organizations
  - Assessed progress and identified gaps
  - Established and prioritized near-term focus areas
- Synthesized feedback into 10 Gap Categories with 18 capability needs. Critical current needs are:
  - Additional test facility capacity to efficiently demonstrate reactors
  - Advanced construction technologies
  - Pilot-scale fuel fabrication capability and fuel design support
- NRIC will work with DOE and stakeholder to develop strategies to address each of the identified gaps.

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Challenges

Challenges over past year:

- Delays in delivery of Government-Furnished Equipment (GFE) pushed out NRIC-DOME construction completion.
  - Advanced reactor testing requires a complex ecosystem
    - Support equipment (fueling/shielding/defueling)
    - NRIC has plan to secure these items and optimize use of NRIC-DOME
- Securing needed program managers, reactor operators and engineering workforce to support rising workload associated with multiple tests
  - Materials and Fuels Complex (MFC) and NRIC continuously hiring

Challenges going forward:

- Budget needs to be sustained and grow
- NRIC/INL/DOE need to move as fast as our industry partners

Benefits of Testing & Demonstration

- **Bridge the gap between development and commercialization:**
  - Providing funding to mature technology readiness and reduce risks to participants for first of a kind build.
  - Facilitate partnership between technology developers, end users, national labs, universities, regulators, industrial participants.
- **Learn by doing reduces risks associated with first commercial build:**
  - Types of materials standardly available in the U.S. vs Europe
  - Optimize design for assembly
  - Establish construction procedures – welding, lifting, NDE, etc.
  - Sequencing of operations
- Builds confidence with regulators, construction entities, and trades
- Develop supply chain

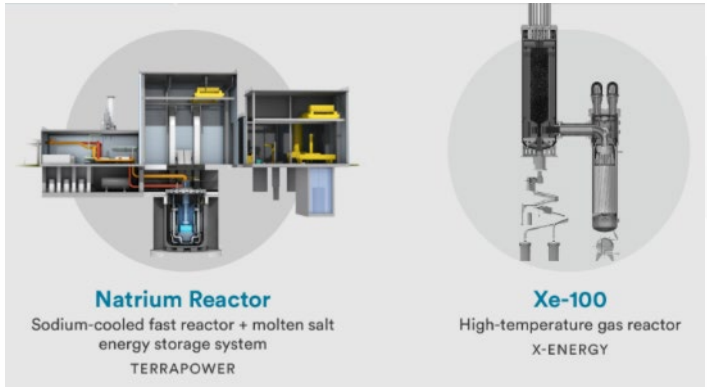
Summary: Key Accomplishments

- **Physical Testbeds:**
  - **NRIC-DOME:**
    - Continued construction
    - Made significant progress toward testing with partners
  - **LOTUS Test Bed:**
    - Completed final design
    - Received construction proposals
- **Digital Tools:**
  - VTB - developed new models and problem sets
  - Scaled digital engineering methods
  - Developed framework for AI assisted DOE authorization
- **Reactor Deployment:**
  - ACTI - Completed testing of samples at PARI
  - Completed feasibility study of addressing nuclear quality assurance challenges
- Prepared the updated gap assessment.

INL Participation in Advanced Reactor Demonstration Program (ARDP) Projects

- 9 projects supported
- Scope range
  - Modeling & Simulation
  - Irradiation & PIE
  - Fuel design & fabrication
- ~$175M – 7 years
  - $1M - $75M per project
- NRIC/INL Coordinator
- NRIC Deployed Digital Engineering and project management tools

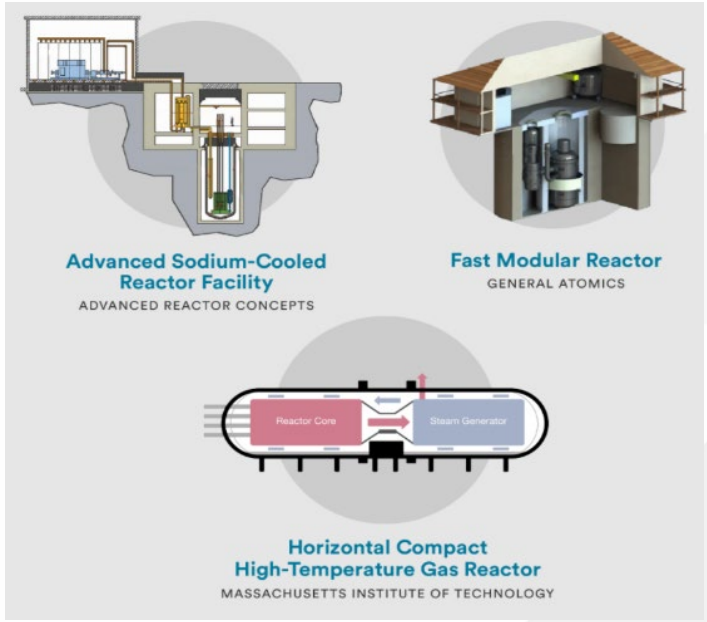
Demonstration



Natrium Reactor
Sodium-cooled fast reactor + molten salt energy storage system
TERRAPOWER

Xe-100
High-temperature gas reactor
X-ENERGY

Concept Development

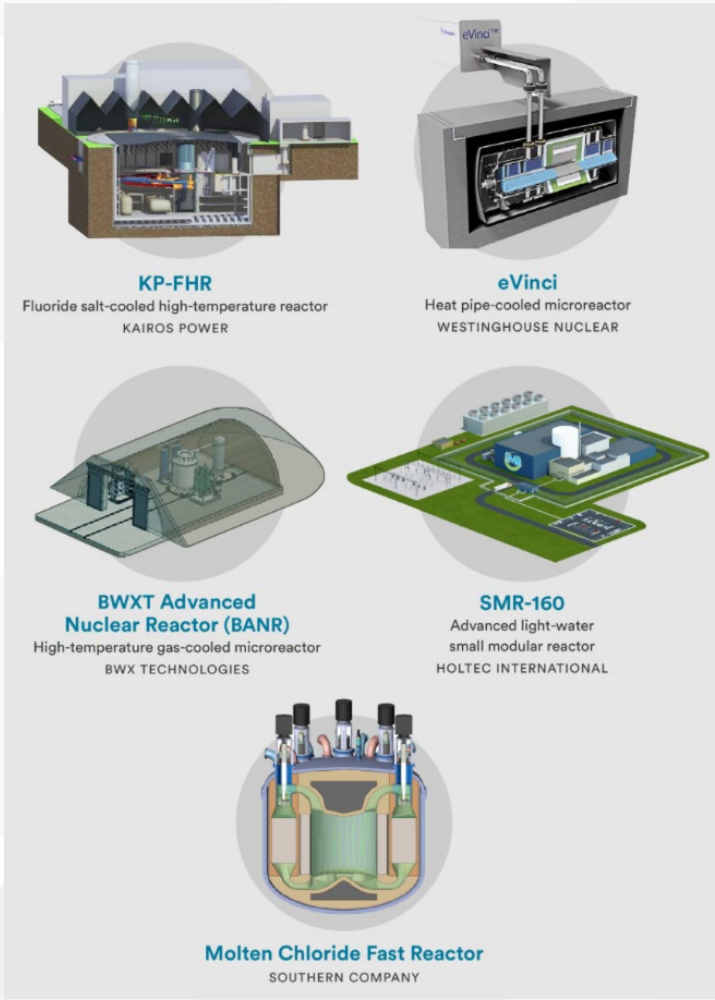


Advanced Sodium-Cooled Reactor Facility
ADVANCED REACTOR CONCEPTS

Fast Modular Reactor
GENERAL ATOMICS

Horizontal Compact High-Temperature Gas Reactor
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Risk Reduction



KP-FHR
Fluoride salt-cooled high-temperature reactor
KAIROS POWER

eVinci
Heat pipe-cooled microreactor
WESTINGHOUSE NUCLEAR

BWXT Advanced Nuclear Reactor (BANR)
High-temperature gas-cooled microreactor
BWX TECHNOLOGIES

SMR-160
Advanced light-water small modular reactor
HOLTEC INTERNATIONAL

Molten Chloride Fast Reactor
SOUTHERN COMPANY

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NRIC Supports Other Reactor Projects Being Planned for INL Site

- **Oklo Aurora Reactor:**
  - Site use agreement in place
  - NRC licensed
  - Fuel fab facility to be constructed at INL
    - DOE authorized
    - CSDR approved by DOE
- **Aalo Atomics:**
  - Siting MOU signed with DOE
  - Planned as DOE authorized test
  - Aalo-X Reactor
  - 20 MWth
- Multiple programs use our configuration management personnel and digital tools.

Questions?

NRIC National Reactor Innovation Center

www.nric.inl.gov