NRIC National Reactor Innovation Center

National Reactor Innovation Center

Program Overview

May 23, 2024

Brad Tomer, Acting Director, Chief Operating Officer

nric.inl.gov

NRIC is a DOE program launched in FY'2020

NRIC Enables Nuclear Reactor Tests & Demonstrations

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

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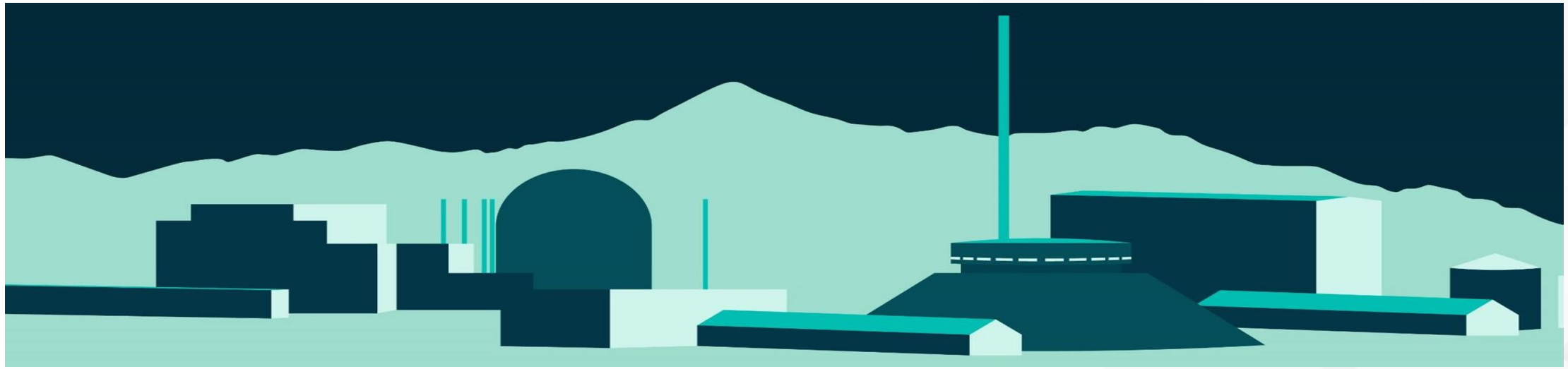
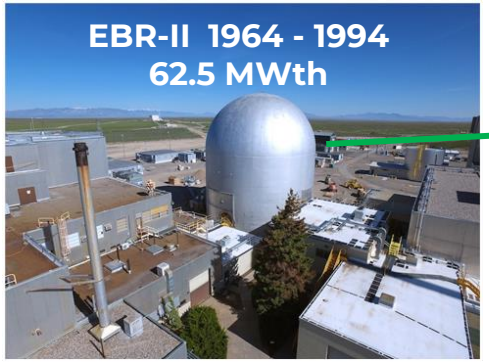
Portfolio Built to Empower Innovators



- **Building testing foundation**
  - Advanced Reactor Test Beds
  - Experimental Facilities
  - Virtual Test Bed
- **Addressing Costs & Markets**
  - Advanced Construction
  - Digital Engineering for Nuclear
  - Maritime Applications

NRIC Advanced Reactor Testbed Capabilities

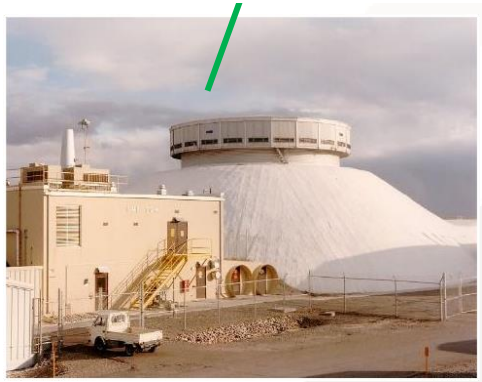


Demonstration of Microreactor Experiments (DOME)

- DOME is the repurposed EBR-II structure
- Designed for Advanced Microreactors up to 20MW_{th}
- Designed for High-Assay Low-Enriched Uranium (HALEU) fuels < 20% enrichment
- Accommodates ISO 668 High-Cube Shipping Containers up to 40ft long.
- 480V / 400Amp electrical Service
- ≈ 78 ft diameter floor space with an 80ft ceiling
- 300kWth of environmental cooling expandable to 500KW_{th}

Materials & Fuels Complex at INL

ZPPR 1969 to 1990
Transuranic and HEU inspection repackaging and experiments

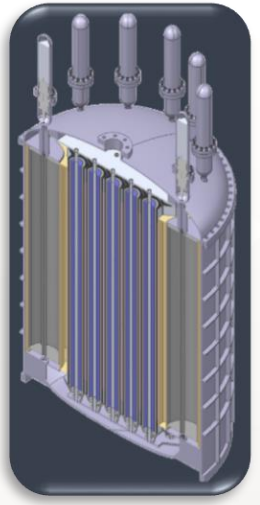


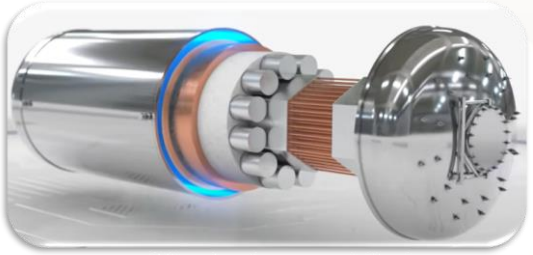
Laboratory for Operations and Testing in the US (LOTUS)

- LOTUS is the repurposed ZPPR structure
- Designed for HEU fuels
- Cell Heat Removal – (2) redundant HVAC packages – 50kWth
- Reactor Heat Removal – Design only – Min: 25KW_{th}; Max: 500 kW_{th}
- In Cell Equipment Power
  - Normal – 480VAC, 450A, 3 phase
  - Auxiliary – 208VAC, 160A, 3 phase
- Cell Provides Radiological Confinement
- Cell Geometry – 30ft usable inner diameter; 16ft 11in (bottom of crane hook); Recessed pit area
- Entry Tunnel – 13ft x 13ft
- Polar Crane Capacity – 5 tons

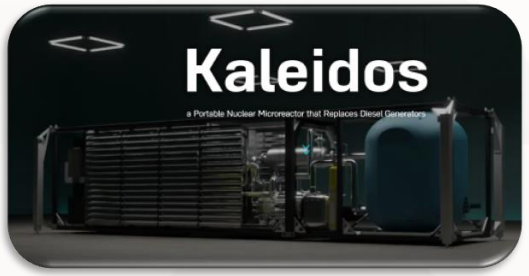
NRIC-DOME Testbed

- Construction Start Q4 2023
- Operational Readiness – June 2026
- First user expected – 2026
- 3 users going through front-end engineering and experiment design



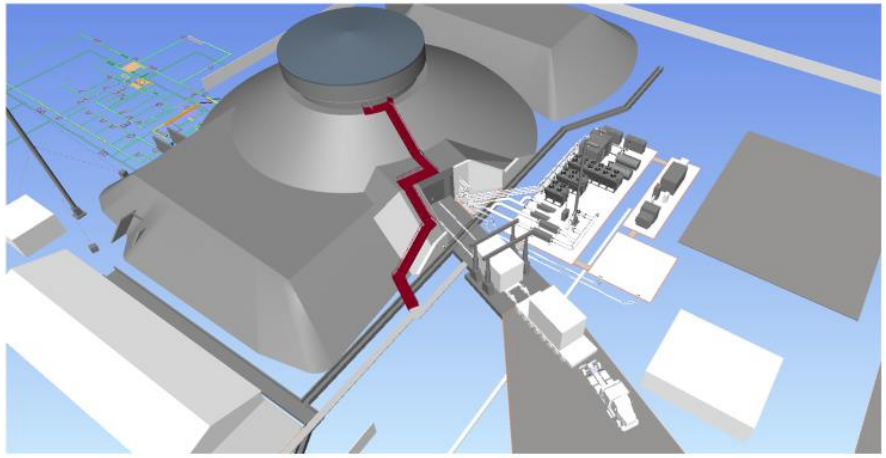


Westinghouse - eVinci

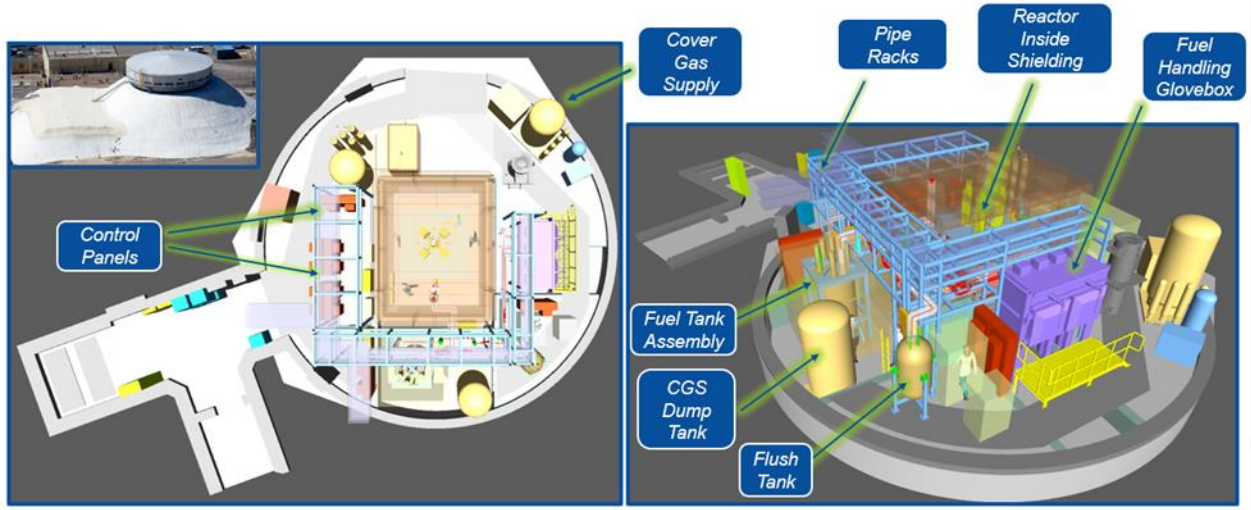


Developer	Reactor Name	Design	Power Mwe	Power MWth	Fuel Type	Fuel Enrichment	Primary Coolant	Moderator	Refueling Interval (Years)	Power Conversion System
Radiant	Kaleidos	HTGR	1.2	3.5	TRISO	19.75%	Helium	Graphite	6	Brayton Cycle
USNC	Pylon	HTGR		1	TRISO	9.90%	Helium	Graphite		Rankine
Westinghouse	eVinci NTR	Heat Pipe	1	3	TRISO	19.75	Sodium	Graphite	8	Brayton Cycle

NRIC-LOTUS Testbed



LOTUS Conceptual Design Model



Molten Chloride Reactor Experiment integrated into LOTUS

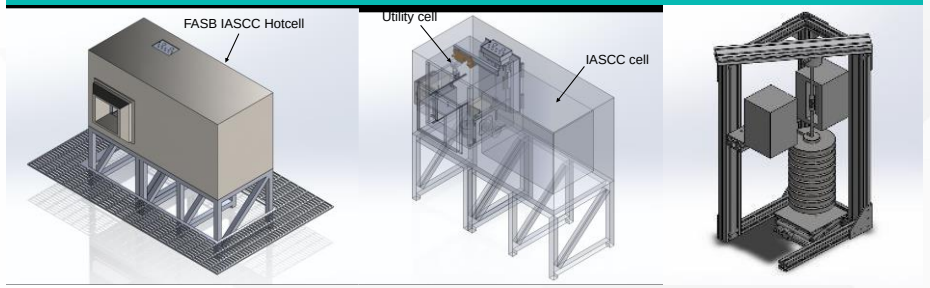
- Line-item project: CD-1 Approved 6/23
- Preliminary design review: Feb 2024
- Complete Construction: FY27
- First User: Molten Chloride Reactor Experiment

- Southern Company & Terra Power
- Funded through DOE Advanced Reactor Demonstration Program Risk Reduction
- Reactor Install: FY27/28

NRIC Experimental Infrastructure

Helium Component Test Facility [*2022*]

In-HotCell Thermal Creep Frame [*2025*]

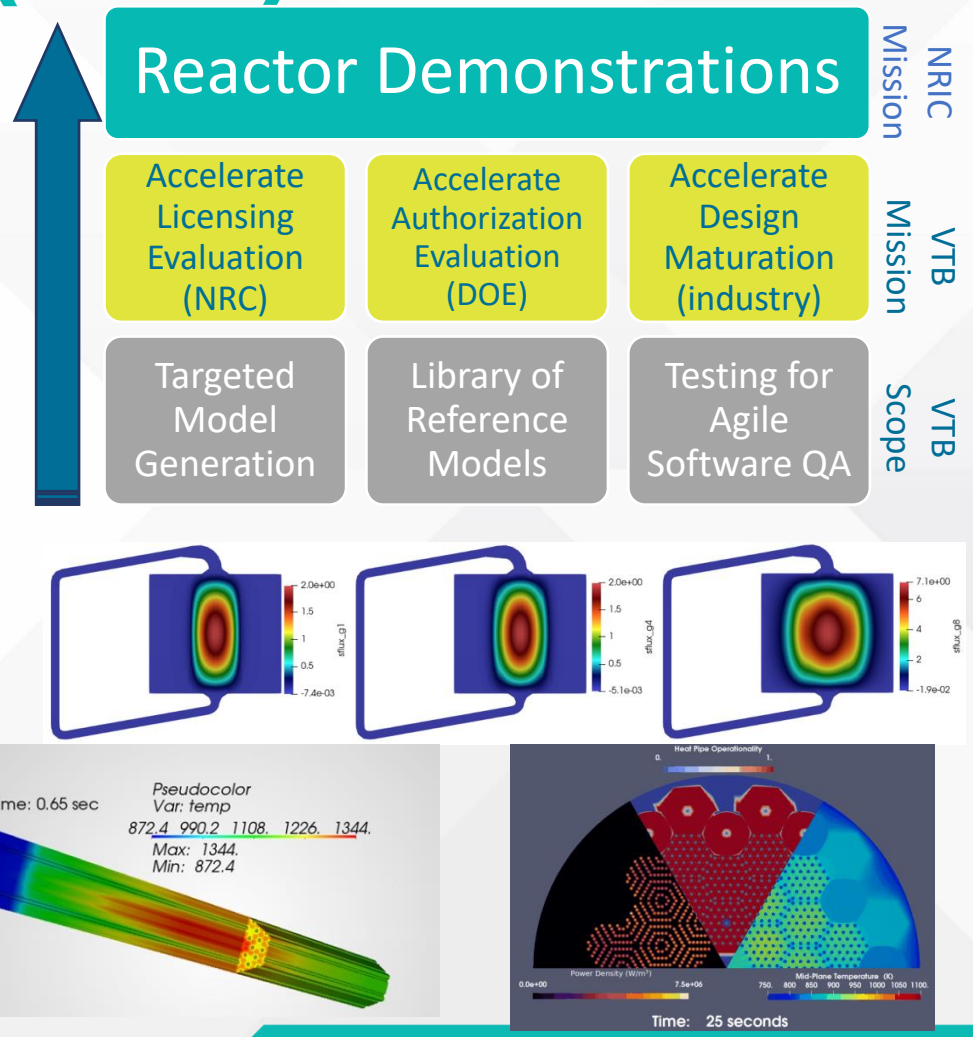


Molten Salt Thermophysical Examination Capabilities (MSTEC) [*2025*]

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

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. Sodium, lead, micro and molten salt reactors (continuously tested)
- Currently hosting 47 distinct models with 15 NEAMS codes
- Averaging 250+ visits/month (period Jan-March 2024)



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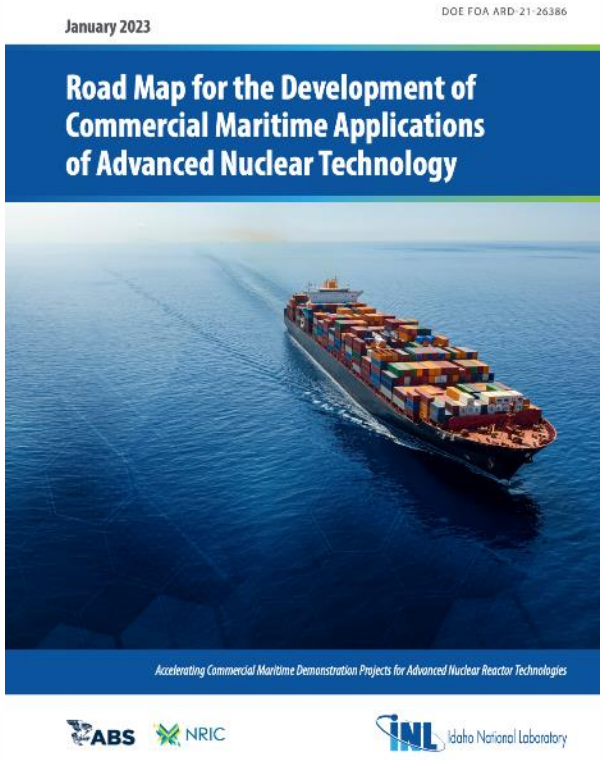
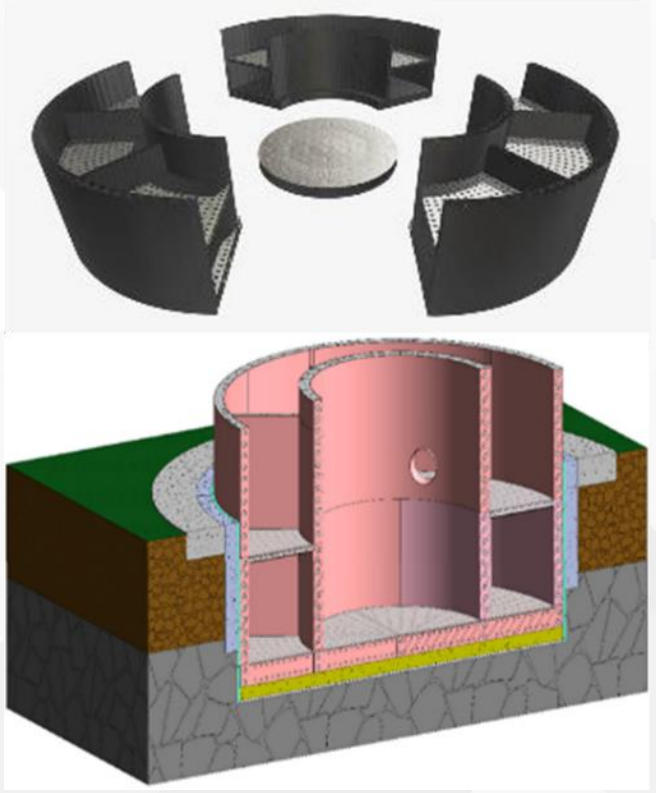
Addressing Cost and Markets

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





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Advanced Construction Technologies

Demonstrate technologies that:

- Reduce cost of new nuclear builds by 10%+
- Compress construction schedule by as much as 25%
- Reduce required site work & improve overall quality of structure
- Support long-term structure monitoring

Phase One (Expected completion July 2024)

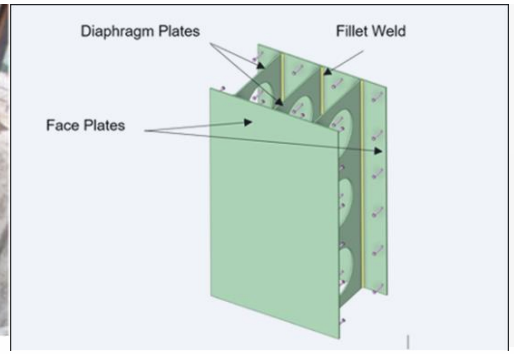
- Prototype modular steel/concrete composite walling system
- Developed non-destructive examination and welding techniques
- Demonstrated strength of wall systems

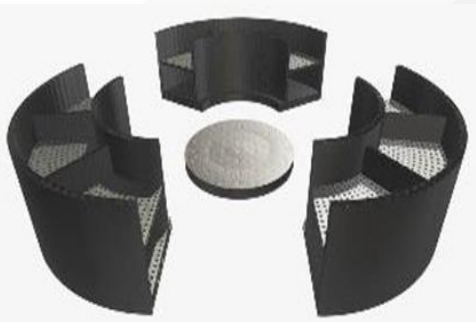
Phase Two (Expected start Sept 2024)

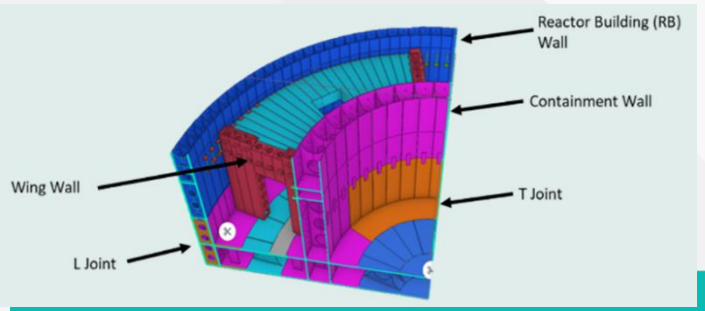
- Demonstrate 60-degree pie shape containment walling system
- Inner and outer walls, base mat integration, multi-story
- Deploy digital twin plus sensor technology for monitoring

Team – General Electric Hitachi

EPRI, Black & Veatch, Purdue, UNCC, Nuclear Advanced Manufacturing Research Centre, Caunton Engineering w/Modular Walling Systems Ltd, Aecon and Tennessee Valley Authority







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Digital Twin – Advanced Construction

- State of the art replica of the structure to integrate sensor data, artificial intelligence, machine learning, and data analytics. Cradle to grave monitoring
- EPRI, University of North Carolina Charlotte, Nuclear AMRC
- Organizes all project data by component and by life-stage
  - Each module with its own rich information, models and sensors
    - Flow of information through the modules - Back and Forth
    - Ability to query, investigate, assess conditions of individual Steel Bricks™ in the structure.
  - Semi-automated procedures to update Building Information Modeling & Finite Element Analysis models from field measurements
  - Long-term monitoring combining structural models with:
    - Earth pressure sensors (lateral stress)
    - LiDAR scans of base, shaft walls and ground surface
    - Procedures to stream data from the field for real-time decision-making via wireless transmission of sensor data

NRC Collaboration

- Congress recognized the importance of agency coordination in the Nuclear Energy Innovation Capabilities Act
- DOE/NRC MOU to “coordinate DOE and NRC technical readiness and sharing of technical expertise and knowledge on advanced nuclear reactor technologies and nuclear energy innovation, including reactor concepts demonstrations, through the [NRIC].”
  - NRIC Rotations

Fred Sock
Office of Nuclear Regulatory Research

Allen Fetter
Office of Nuclear Reactor Regulation

- Monthly Coordination Calls – DOE/NRC/NRIC

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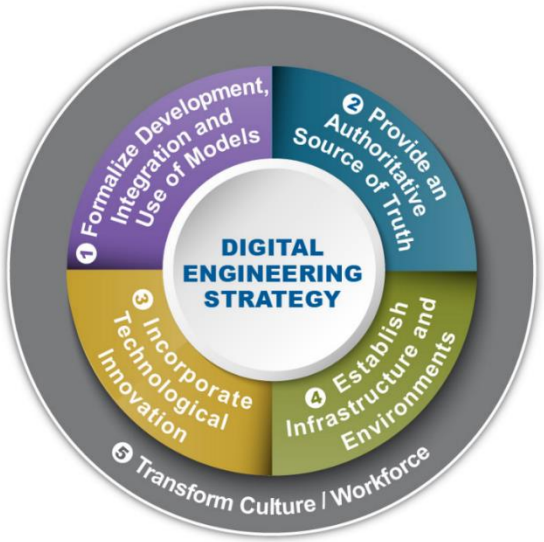
Digital Engineering (DE)



- **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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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
- 120 members representing 40+ companies
- Gap assessment of testing capabilities for maritime nuclear applications

ABS iFOA Award

- DOE Readiness Report (Task 3)
- Upcoming: Overcoming Barriers to Nuclear-Maritime Demonstrations (Task 4)

Nuclear Energy University Program

*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.*

THE UNIVERSITY OF TEXAS AT DALLAS

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5/21/2024

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