U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Advanced Sensors and Instrumentation

Advanced Sensors and Instrumentation (ASI) Program Overview

Advanced Sensors and Instrumentation (ASI) Program Annual Review Webinar

Nov. 4, 6-7, 2024

Federal Program Manager: *Daniel Nichols, PhD*

U.S. Department of Energy, Office of Nuclear Energy

Administrative Items

The FY24 Advanced Sensors and Instrumentation (ASI) annual program review webinar will run 3 days: Nov. 4th, 6th, & 7th.

The program review contains presentations in the following categories:

18	Directed Research Projects	6	CINR Awards
7	SBIR/STTR Awards		

Goals:

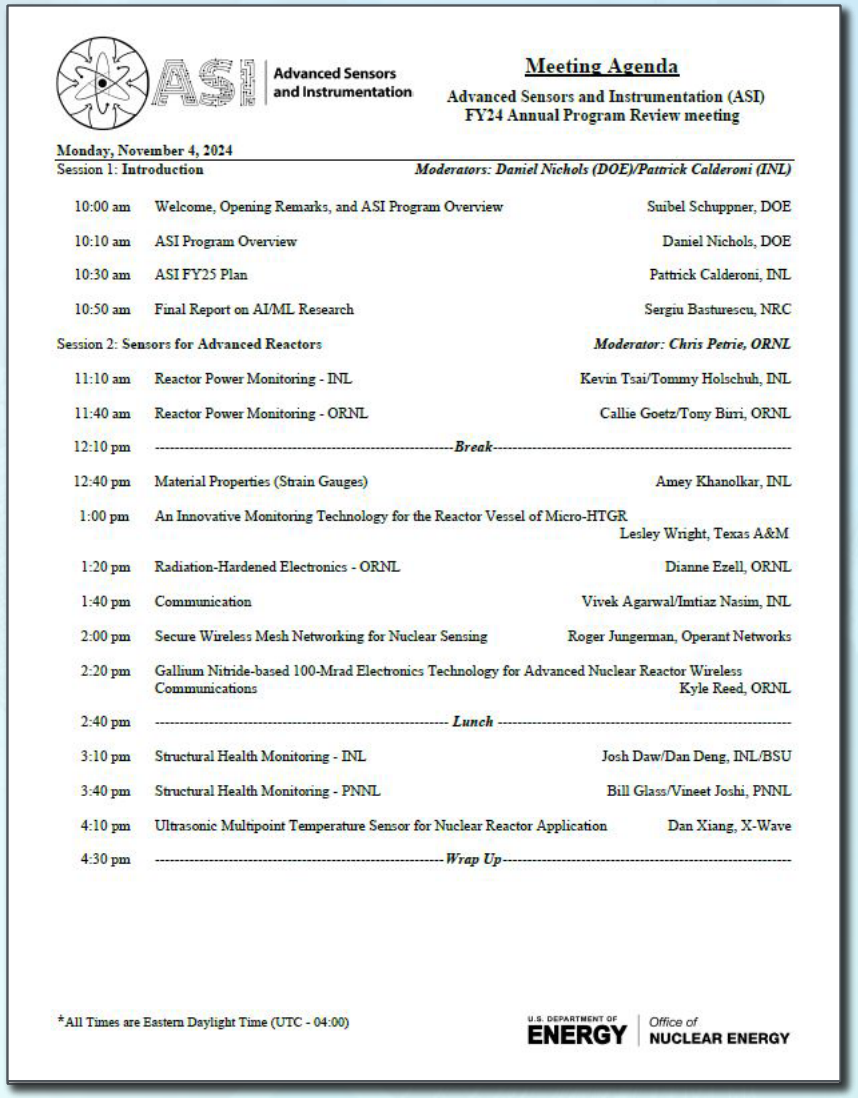
- Complete Annual Review of all ASI program projects
- Provide broad programmatic information for stakeholders throughout NE industry
- Provide detailed project status presentations to inform NE community of progress

Expected Outcomes:

- Allow for productive dialogue about ongoing work
- Ongoing projects gain visibility with NE industry stakeholders
- Receive feedback from NE community on the ASI program and projects

For webinar-related technical support, please contact Hyrum Ray:

hyrum.wray@inl.gov -or- (208) 715-1449



ASI Advanced Sensors and Instrumentation

Meeting Agenda

Advanced Sensors and Instrumentation (ASI)
FY24 Annual Program Review meeting

Monday, November 4, 2024

Session 1: Introduction		***Moderators: Daniel Nichols (DOE)/Patrick Calderoni (INL)***
10:00 am	Welcome, Opening Remarks, and ASI Program Overview	Suibel Schuppner, DOE
10:10 am	ASI Program Overview	Daniel Nichols, DOE
10:30 am	ASI FY25 Plan	Patrick Calderoni, INL
10:50 am	Final Report on AI/ML Research	Sergiu Basturescu, NRC
Session 2: Sensors for Advanced Reactors		***Moderator: Chris Petrie, ORNL***
11:10 am	Reactor Power Monitoring - INL	Kevin Tsai/Tommy Holschuh, INL
11:40 am	Reactor Power Monitoring - ORNL	Callie Goetz/Tony Birri, ORNL
12:10 pm	***Break***	
12:40 pm	Material Properties (Strain Gauges)	Amey Khanolkar, INL
1:00 pm	An Innovative Monitoring Technology for the Reactor Vessel of Micro-HTGR	Lesley Wright, Texas A&M
1:20 pm	Radiation-Hardened Electronics - ORNL	Dianne Ezell, ORNL
1:40 pm	Communication	Vivek Agarwal/Imtiaz Nasim, INL
2:00 pm	Secure Wireless Mesh Networking for Nuclear Sensing	Roger Jungerman, Operant Networks
2:20 pm	Gallium Nitride-based 100-Mrad Electronics Technology for Advanced Nuclear Reactor Wireless Communications	Kyle Reed, ORNL
2:40 pm	***Lunch***	
3:10 pm	Structural Health Monitoring - INL	Josh Daw/Dan Deng, INL/BSU
3:40 pm	Structural Health Monitoring - PNNL	Bill Glass/Vineet Joshi, PNNL
4:10 pm	Ultrasonic Multipoint Temperature Sensor for Nuclear Reactor Application	Dan Xiang, X-Wave
4:30 pm	***Wrap Up***	

*All Times are Eastern Daylight Time (UTC - 04:00)

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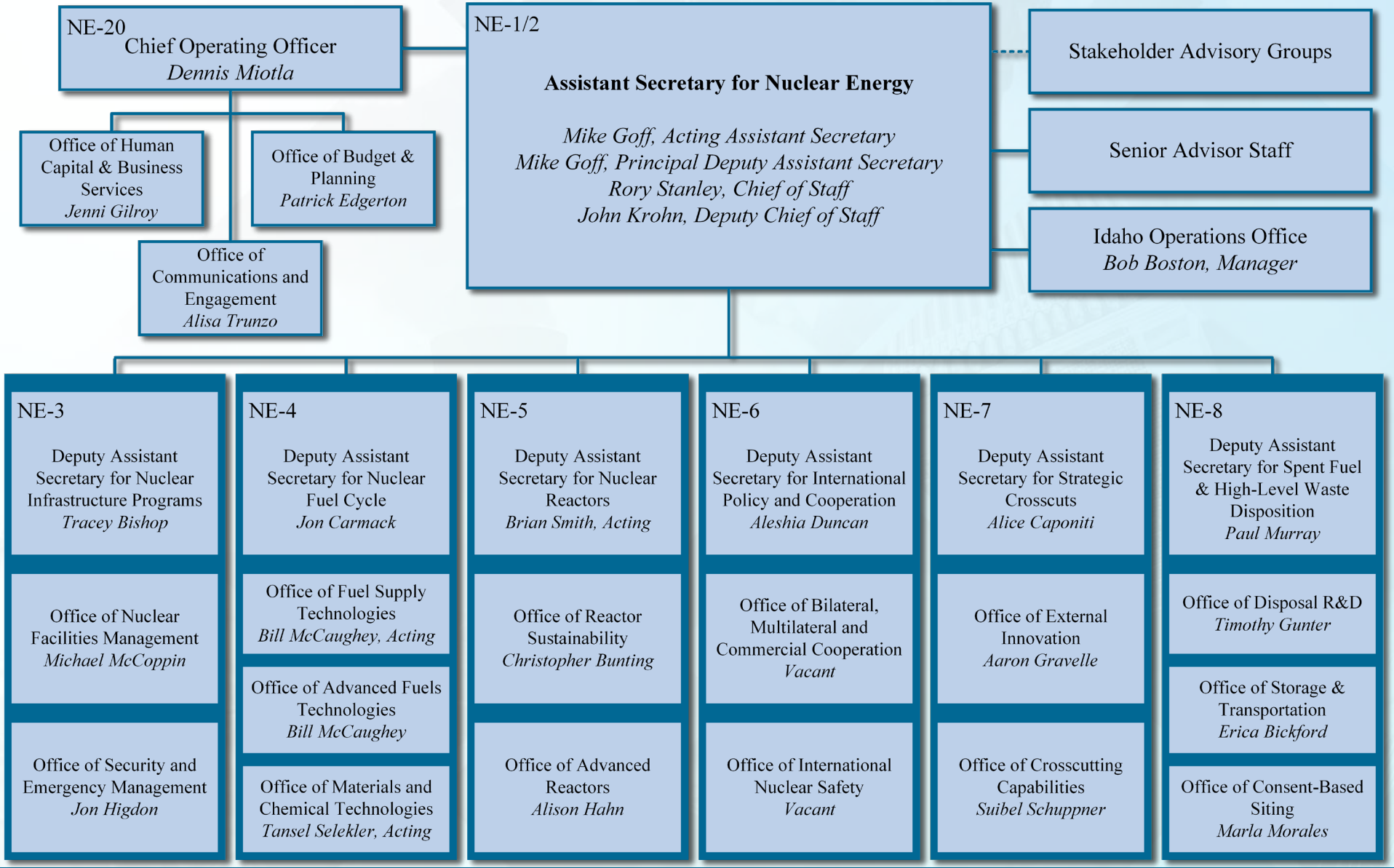
Structure of the Office of Nuclear Energy



Advanced Sensors and Instrumentation Leadership

Federal Program Manager: Daniel Nichols

daniel.nichols@nuclear.energy.gov

National Technical Director: Pattrick Calderoni

pattrick.calderoni@inl.gov

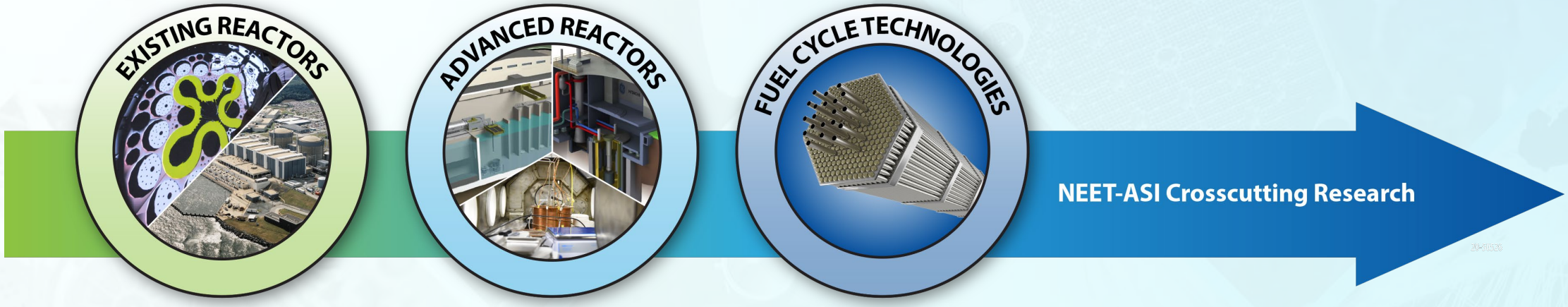
ASI Program Focus

Mission

Develop **advanced sensors and I&C** that address **critical technology gaps** for monitoring and controlling existing and advanced **reactors** and supporting **fuel cycle** development

Vision

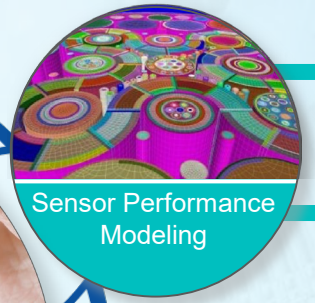
NEET ASI Research results in advanced sensors and I&C technologies that are **qualified, validated, and ready to be adopted by the nuclear industry**



ASI R&D Components

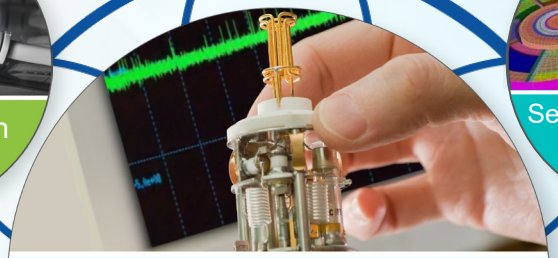
Resilient, real-time transmission of sufficient amount of data for online monitoring and advanced data analytics

Communication



Modeling of instrumentation performance to enable predictive capabilities and integration in Digital Twins

Sensor Performance Modeling

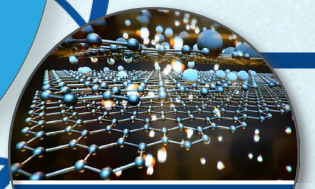


Sensors and Instrumentation

Reliable, cost-effective, real-time, accurate, and high-resolution measurement of the performance of existing and advanced reactors core and plant systems

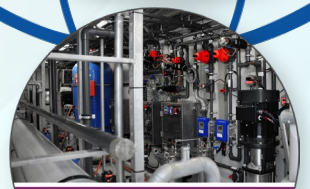
Machine learning and artificial intelligence processes to enable semi-autonomous operation and maintenance by design

Big data, Machine Learning, Artificial Intelligence



Innovative sensor materials and advanced manufacturing techniques applied to instrumentation design and fabrication

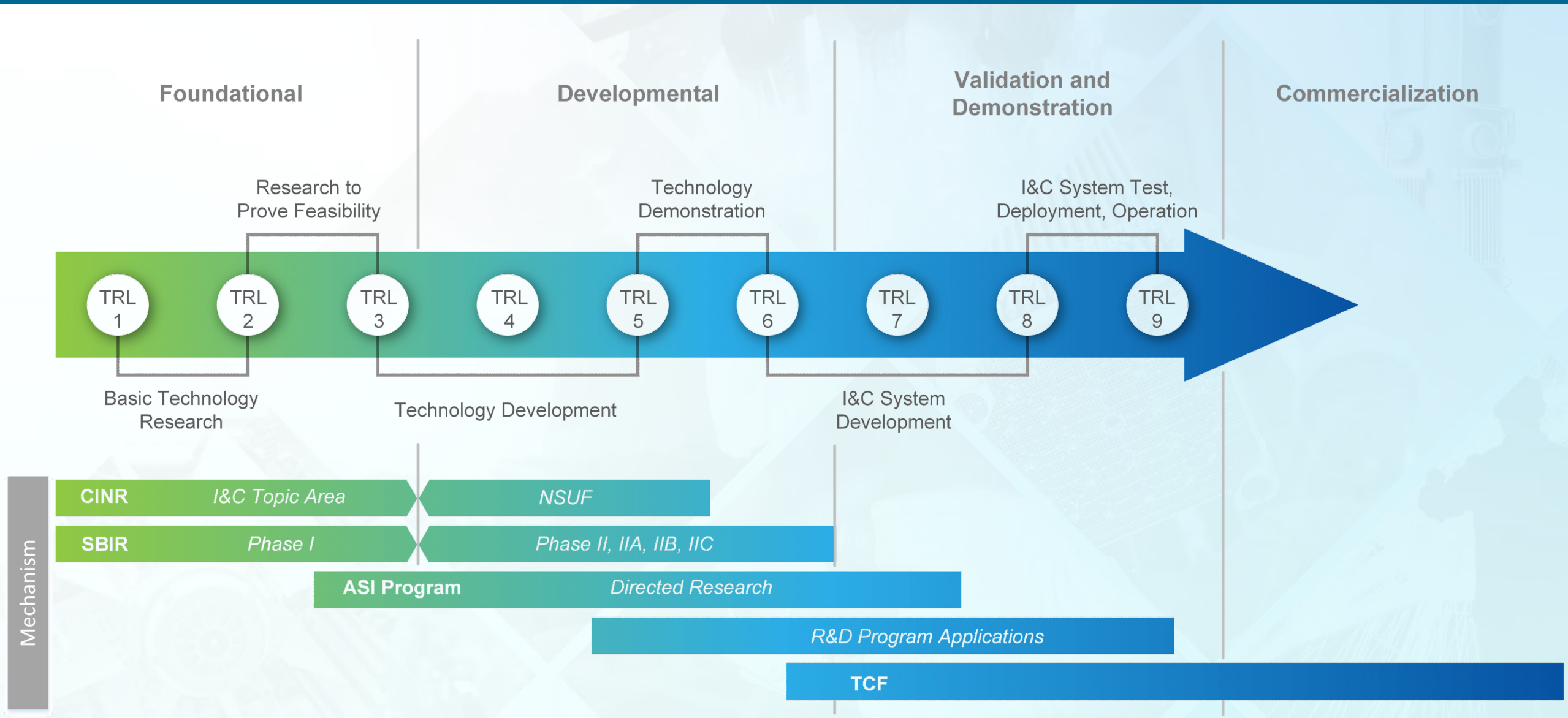
Material Science



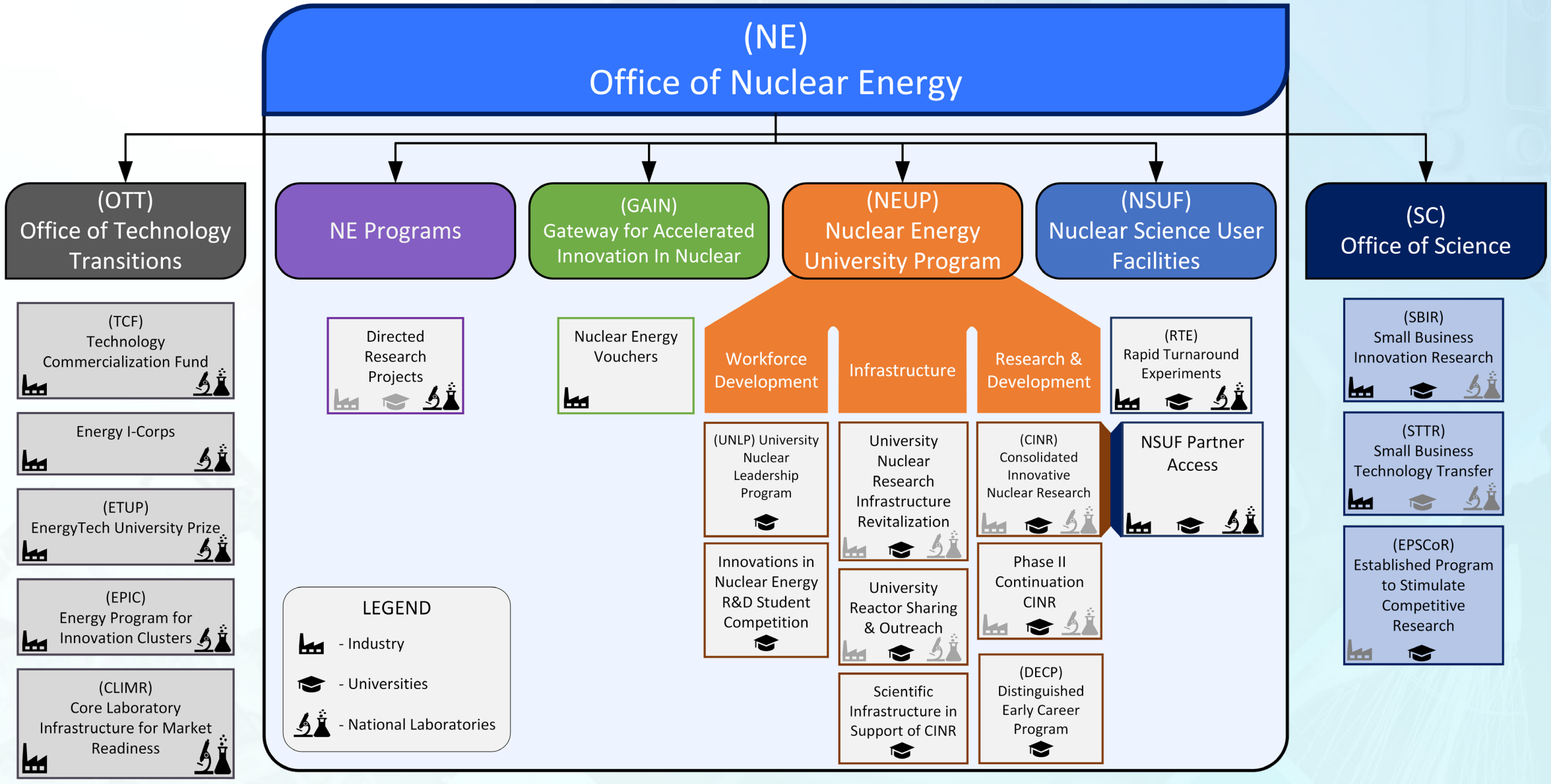
Advanced Control Systems

Enable near real-time control of plant or experiments process variables to enhance performance

Methods and Metrics of ASI Research



NE R&D Funding Map



Program-related Funding Opportunities

	Universities	National Laboratories	Industry
Consolidated Innovative Nuclear Research (CINR)	Principal Investigator/Sub-awardee for: – Integrated Research Projects (IRP) – Research & Development (R&D) – Nuclear Science User Facility (NSUF) access only	Principal Investigator/Sub-awardee for: – Nuclear Science User Facility (NSUF) access only Sub-awardee for: – Integrated Research Projects (IRP) – Research & Development (R&D)	Principal Investigator/Sub-awardee for: – Nuclear Science User Facility (NSUF) access only Sub-awardee for: – Integrated Research Projects (IRP) – Research & Development (R&D)
Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR) programs	Engage and collaborate with a small business to commercialize the technology	Engage and collaborate with a small business to commercialize the technology	Lead the commercialization effort as the Principal Investigator
Directed Research	Collaborate with National Laboratory as a subcontractor	Lead R&D efforts as the Principal Investigator	Collaborate with National Laboratory as a subcontractor

Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)

SBIR and STTR focus on industry-led projects with the intent to advance technologies to commercialization

Key Upcoming Dates:

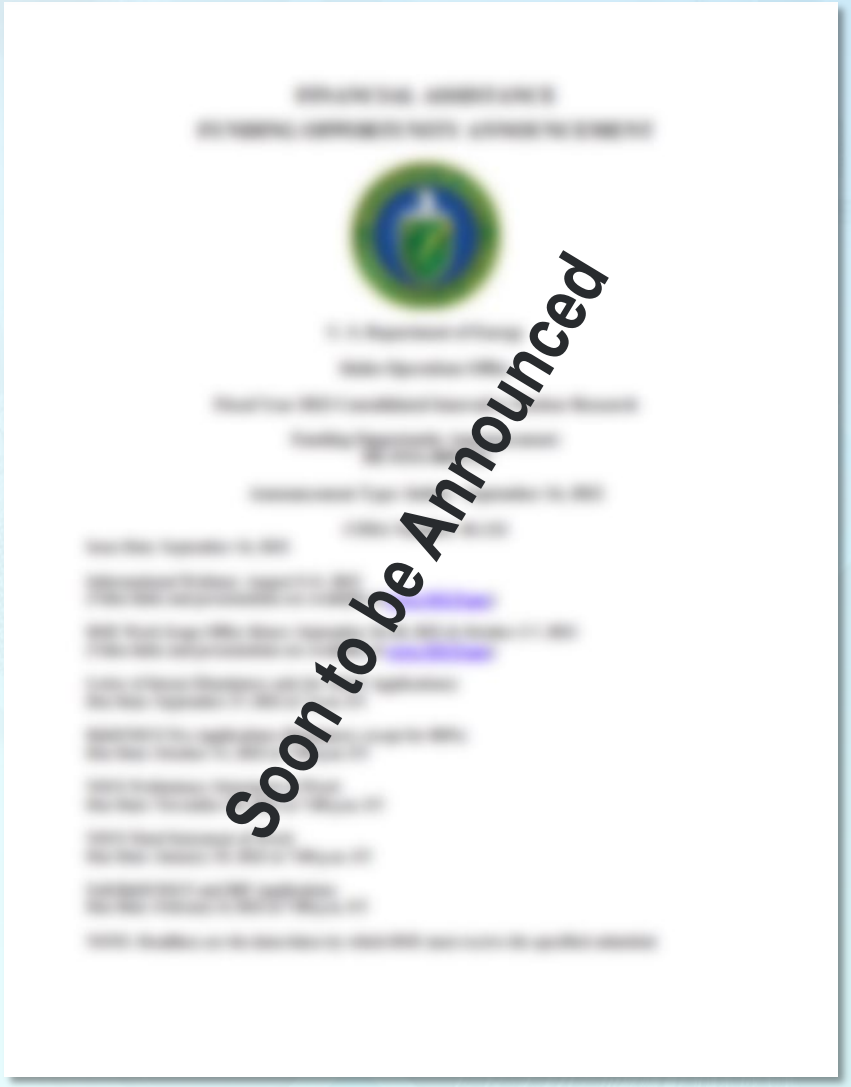
Topic Issues	Nov. 12, 2024
Topic Webinar	Nov. 18, 2024 (tent.)
FOA issued	Dec. 16, 2024
FOA Webinar	Dec. 19, 2024 (tent.)
Letters of Intent	Jan. 7, 2025
Full Applications	Fed. 26, 2025

For more information about the DOE SBIR/STTR FOA, visit:

https://science.osti.gov/sbir/Funding-Opportunities

For more general SBIR/STTR information, visit:

https://www.sbir.gov/



Active SBIR/STTR Awards (ASI related work)

Subtopic	Phase	Institution	Location	Concluding Fiscal Year	PI	Title
29d	I	Innoveyda	Lake Forest, CA	2025	Indu Saxena	Extreme Temperature Transducer for Enabling Ultrasonic Flowmetry
29d	I	Intelligent Optical Systems, Inc.	Torrance, CA	2025	Bradley Bobbs	In-Reactor Laser Ultrasonic Sensor for Fuel Rod Pressure and Fission Gas
37a	IIB	Intelligent Optical Systems, Inc.	Torrance, CA	2026	Bradley Bobbs	Advanced Laser Ultrasonic Sensor for Fuel Rod Characterization
33a	IIB	Alphacore Inc	Tempe, AZ	2025	Esko Mikkola	Video Camera for Harsh Environments in Nuclear

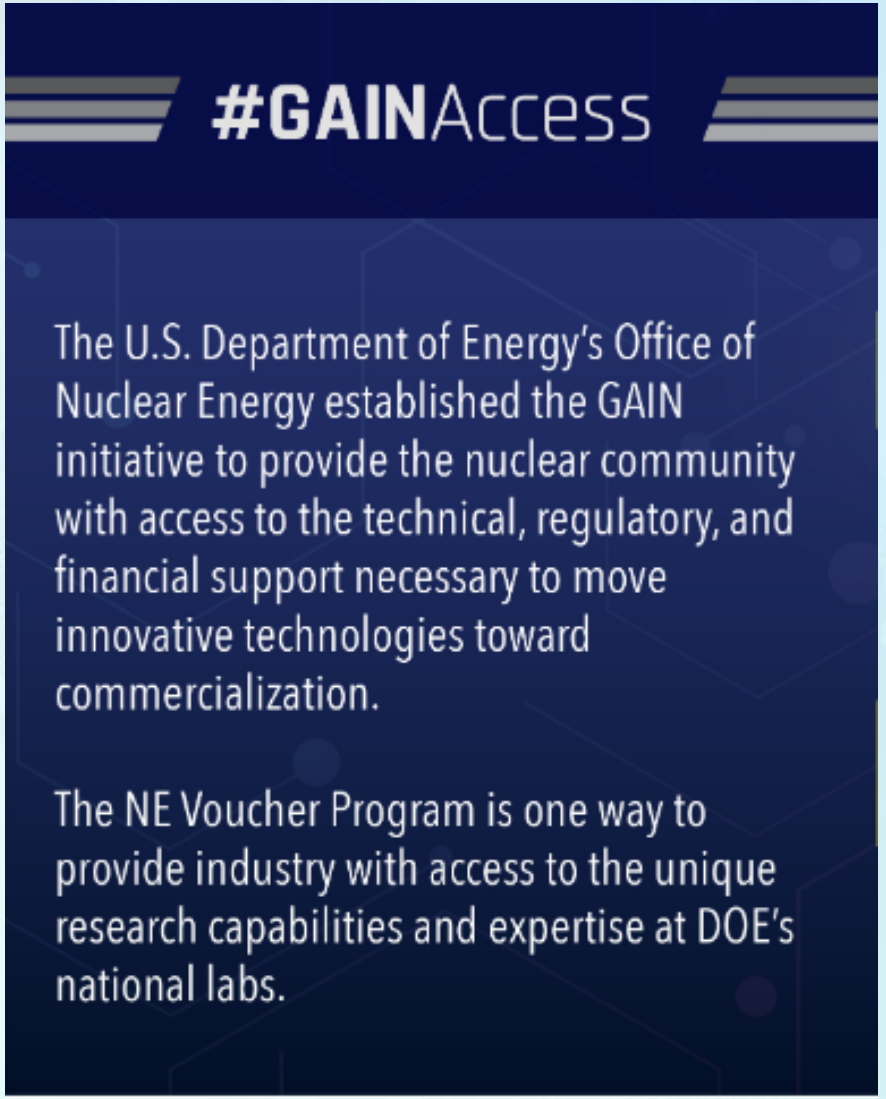
Other Industry-relevant FOAs

Gateway for Accelerated Innovation in Nuclear (GAIN) Vouchers for FY2024:

- **Round 1 – Applications due Oct. 31, 2024 (5:00pm EST)**
- **Round 2 – Applications due Jan. 31, 2025 (5:00pm EST)**
- **Round 3 – Applications due Apr. 30, 2025 (5:00pm EST)**
- **Round 4 – Applications due Jul. 31, 2025 (5:00pm EST)**

More information about both FOAs can be found of the GAIN website:

gain.inl.gov



Consolidated Innovative Nuclear Research (CINR)

Consolidated Innovative Nuclear Research (CINR) holds various opportunities:

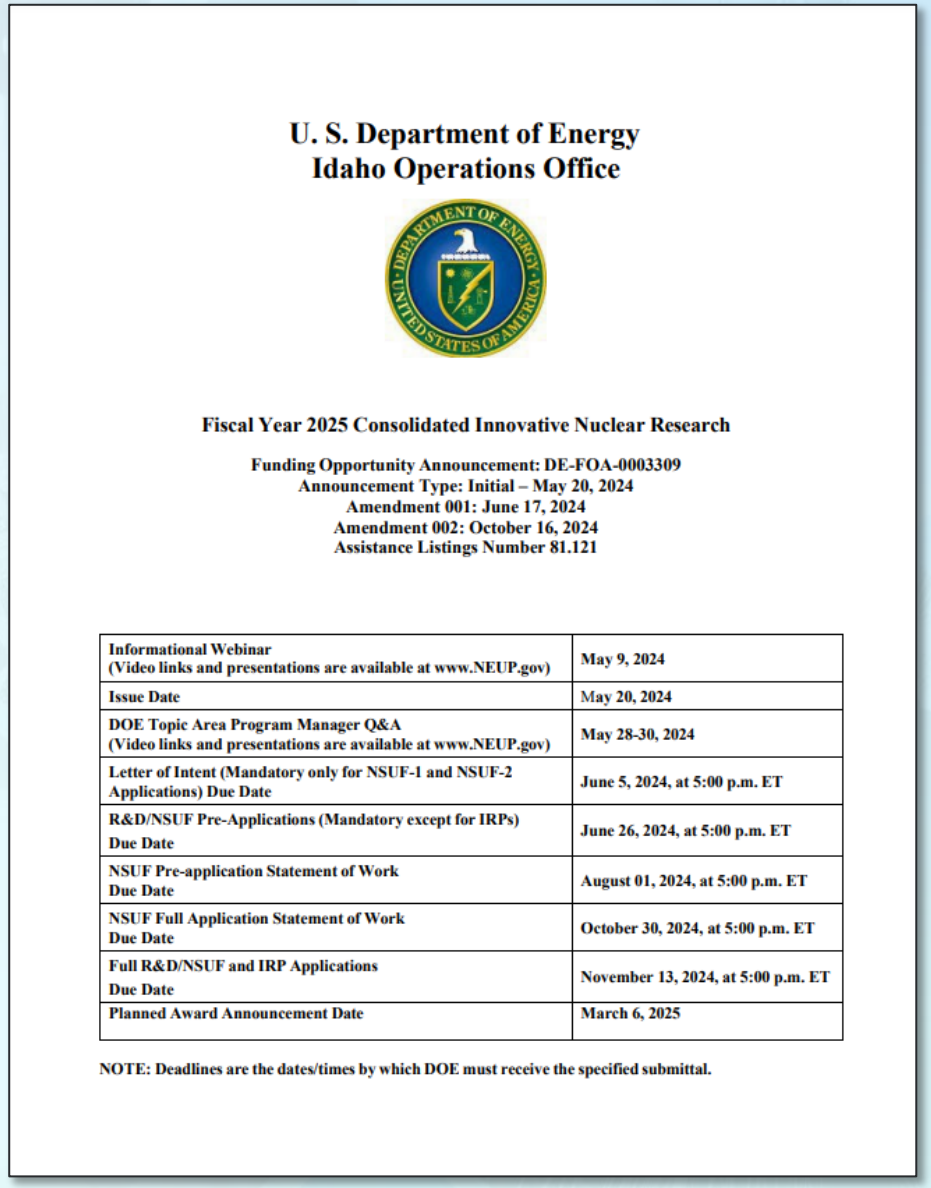
1) U.S. University-led R&D Projects
2) U.S. University-led Integrated Research Projects (IRPs)
3) U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF) Access Only Projects

Key Upcoming Dates:

Full R&D/NSUF and IRP Applications Due Date	**November 13, 2024, at 5:00 p.m. ET**
Planned Award Announcement Date	**March 6, 2025**

For more information visit the NEUP website:

neup.inl.gov/open-funding-opportunities/



U. S. Department of Energy
Idaho Operations Office

Fiscal Year 2025 Consolidated Innovative Nuclear Research

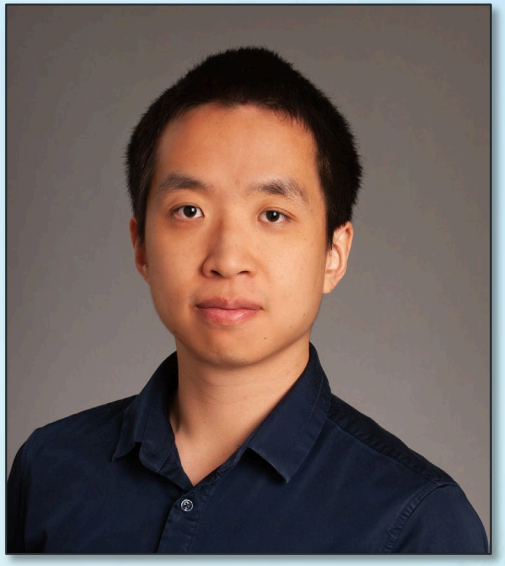
Funding Opportunity Announcement: DE-FOA-0003309
Announcement Type: Initial – May 20, 2024
Amendment 001: June 17, 2024
Amendment 002: October 16, 2024
Assistance Listings Number 81.121

Informational Webinar (Video links and presentations are available at www.NEUP.gov)	May 9, 2024
Issue Date	May 20, 2024
DOE Topic Area Program Manager Q&A (Video links and presentations are available at www.NEUP.gov)	May 28-30, 2024
Letter of Intent (Mandatory only for NSUF-1 and NSUF-2 Applications) Due Date	June 5, 2024, at 5:00 p.m. ET
R&D/NSUF Pre-Applications (Mandatory except for IRPs) Due Date	June 26, 2024, at 5:00 p.m. ET
NSUF Pre-application Statement of Work Due Date	August 01, 2024, at 5:00 p.m. ET
NSUF Full Application Statement of Work Due Date	October 30, 2024, at 5:00 p.m. ET
Full R&D/NSUF and IRP Applications Due Date	November 13, 2024, at 5:00 p.m. ET
Planned Award Announcement Date	March 6, 2025

NOTE: Deadlines are the dates/times by which DOE must receive the specified submittal.

FY24 CINR Recipient for Workscope Topic Area 9: Measuring, Monitoring and Controls

Project Title: Magnetostrictive Guided-wave Transducers for Nuclear Reactor Piping System Monitoring



Principal Investigator: Dr. Zhangxian (Dan) Deng (Boise State University)

Summary: This project aims to develop a novel magnetostrictive guided-wave structural health monitoring system for nuclear reactor piping to enable continuous, condition-based monitoring and reduce maintenance costs. Our team will focus on using Galfenol, an iron-gallium alloy known for its high-temperature and radiation resistance, for ultrasonic transducers development. The project's objectives include directly printing Galfenol onto stainless steel to simplify sensor integration, creating a comprehensive SHM system with user-friendly interfaces, and validating system performance under extreme conditions at the Ohio State University's research reactor. Success in this endeavor is expected to improve damage prognosis, reduce operational costs, and enhance safety in nuclear reactors.

Project Period: 8/1/2024 – 07/30/2027

BOISE STATE UNIVERSITY

FY24 CINR Recipient for Workscope Topic Area 9: Measuring, Monitoring and Controls

Project Title: Monitoring Ceramic Fuel Fracture via Fiber Optic Acoustic Emission Sensors

Principal Investigator: Dr. Gary Pickrell (Virginia Polytechnic Institute and State University)

Summary: In this program, the Center for Photonics Technology (CPT) at Virginia Tech will collaborate with Sentek Instrument and Idaho National Laboratory (INL) to develop and demonstrate a distributed acoustic emission (AE) sensing system for in-situ monitoring of ceramic fuel fracture and structural components in nuclear power plants. The proposed monitoring system leverages a proven fiber optic technique to interrogate hundreds of grating-based distributed interferometers inscribed in best-in-class radiation tolerant single mode optical to fiber to obtain ultra-sensitive vibration measurements that can be configured with high spatial resolution and sampling rates. The relatively small diameter optical fiber will be wrapped around the DRIFT (Dry in-pile fracture test) stainless steel insert assembly to obtain at least 20 sensor measurements with an approximate spatial resolution of 2.5 mm along the plane parallel to the centerline of the uranium oxide pellet stack. Laboratory scale testing will be performed at VT to optimize the sensor configuration and demonstrate performance of the prototype sensing system using a surrogate fuel material. The program will culminate with the integration of the prototype sensing system at a selected test reactor facility.

Project Period: 8/1/2024 – 07/30/2027

VIRGINIA TECH

FY24 CINR Recipient for Workscope Topic Area 10: Licensing, Safety, and Security

Project Title: Inference of flow conditions from in-core detector measurements for accelerating SMR licensing

Principal Investigator: Dr. Benoit Forget (Massachusetts Institute of Technology)

Summary: Reactor modelling relies on the detailed description of reactor systems but often lacks the true as-built characteristics of a system and cannot realistically model impactful details a priori. This lack of knowledge can lead to large discrepancies between the observables and modelling and simulation predictions, and in real production system there is often insufficient instrumentation and access to correct this lack of information. This proposal aims to use all the information available between measurements and simulations to infer key knowledge gaps. A demonstration of this insufficiency will be performed on the low power physics tests of the BEAVRS benchmark where a significant tilt is observed in the initial core hypothesize to be due to fuel bowing. For fresh fuel, the largest contribution to fuel bowing comes from hydraulic forces caused by the inlet flow. Many studies have demonstrated that core inlet flow is often non-uniform during the unfortunate symmetrical design of the cold and hot leg nozzles, which induces a non-symmetrical flow distribution which is impacted by the pumps start up sequence and can further lead to unstable flow switching referred to as “lower plenum flow anomaly” (LPFA). The goal of this proposal is to develop a framework that can learn from all of the reactor information available (like detector signals) and apply it to our demonstration problem to identify fuel bowing distribution and flow disparities in the as-built conditions. The framework will also provide support to the NuScale SMR where accurate inlet flow conditions can be very important in defining margins to critical heat flux.

Project Period: 8/1/2024 – 07/30/2027

Collaborators:

Massachusetts Institute of Technology

Emilio Baglietto
Associate Department Head and Professor of Nuclear Science and Engineering

University of Michigan

Majdi Radaideh (RAD)
Assistant Professor

Kent Welter
NuScale – Chief Engineer, Testing & Analysis

Jason Christensen
Idaho National Laboratory – Senior Regulatory Engineer

Massachusetts Institute of Technology

FY24 CINR Recipient for Workscope Topic Area 10: Licensing, Safety, and Security

Project Title: Non-Destructive Plutonium Assay in Pyroprocessing Bulk Materials with a 3D Boron-Coated-Straw Detector Array

Principal Investigator: Dr. Angela Di Fulvio (University of Illinois at Urbana-Champaign)

Summary: The once-through fuel cycle adopted in the U.S. does not include reprocessing or recycling of used fuel and leads to inefficient utilization of nuclear fuel, generating a significant volume of high-level waste. Advanced separation technologies have the potential to address these challenges and enable commercially viable reprocessing of used nuclear fuel from the current light-water reactor fleet. Among the most mature of these separation methods is pyroprocessing, which dissolves metal-based spent fuel in a molten-salt bath and minimizes the proliferation risk because it does not produce a pure plutonium stream. This project aims to further enhance the proliferation resistance of pyroprocessing by accurately assessing plutonium content during the process. The strategy involves developing and demonstrating a novel 3D boron-coated-straw neutron detector array (3D-BCSDA) with high efficiency and spatial resolution. While several destructive assay methods have been developed for nuclear material accountability, an NDA system specific to the assessment of bulk materials, including the ability to withstand harsh pyroprocessing environments and account for the fuel form factor, is not available. We will develop the 3D-BCSDA to fill this technology gap. The 3D-BCSDA will offer exceptional gamma-ray rejection for spent-fuel assay, three-dimensional neutron detection for tomographic sample imaging, and sample-dependent multiplicity assay. The anticipated innovations are poised to enhance plutonium assay precision by approximately 60% in bulky plutonium-bearing samples in pyroprocessing.

Project Period: 8/1/2024 – 07/30/2027

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

ASI Program Resources

Visit the DOE-NE website:

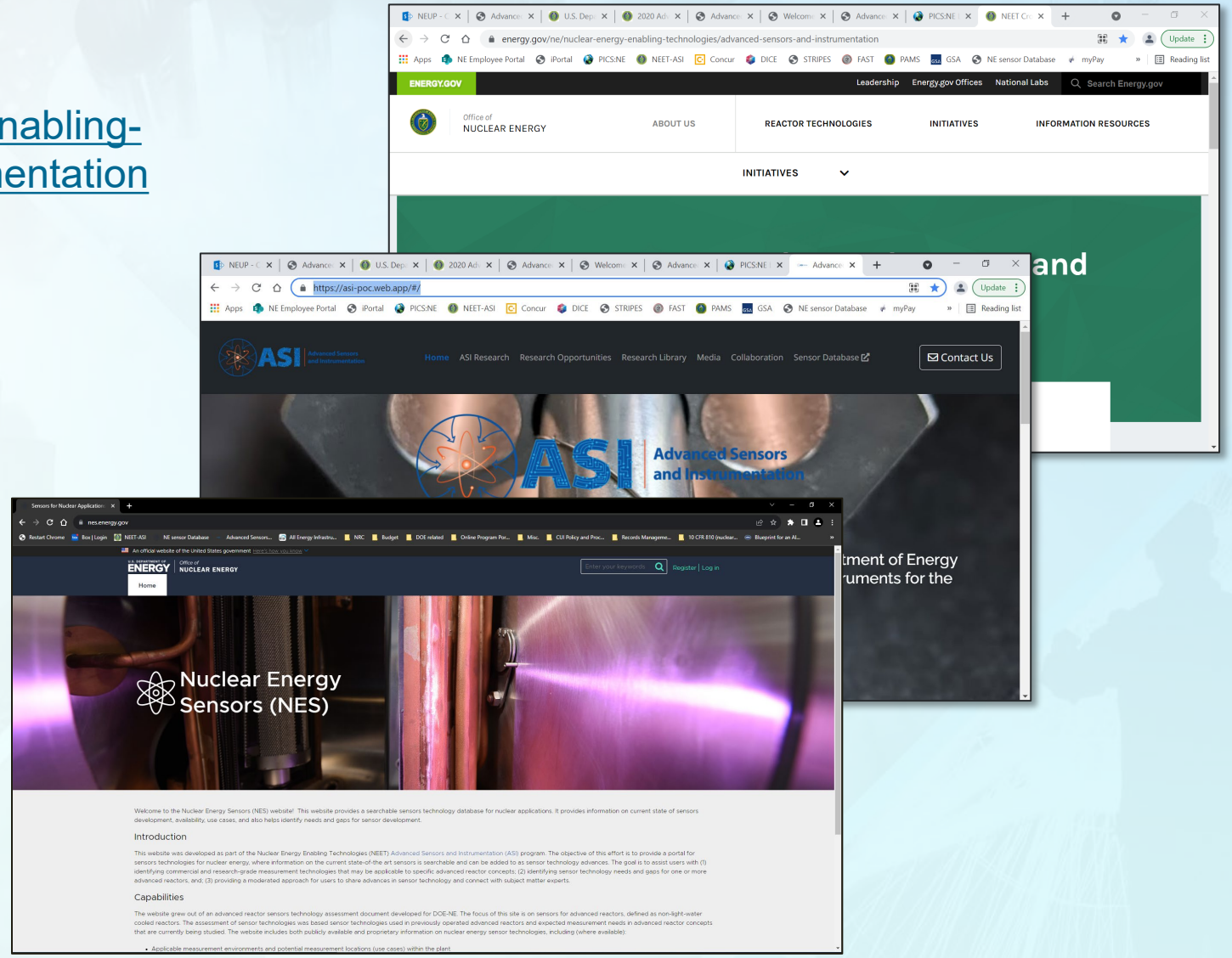
https://www.energy.gov/ne/nuclear-energy-enabling-technologies/advanced-sensors-and-instrumentation

Checkout the new ASI website:

asi.inl.gov

Visit the Nuclear Energy Sensor Database:

https://nes.energy.gov



Concluding Remarks

- Improvements and advancements in ASI technologies will
  - enable advances in nuclear reactor and fuel cycle system development
  - enhance economic competitiveness for nuclear power plants, and
  - promote a high level of nuclear safety

- NEET-ASI research produces concepts, techniques, capabilities, and equipment that are or can be demonstrated in simulated or laboratory test bed environments representative of nuclear plant systems or fuel cycle systems

- Innovative and crosscutting research is funded through competitive, peer-reviewed, solicitations and directed work

Daniel M. Nichols, PhD

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Advanced I&C technologies are an integral component for advanced reactors to provide safe, clean, and reliable power

Thank You