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

ASI Advanced Sensors and Instrumentation

Advanced Sensors and Instrumentation (ASI) Program Overview

Advanced Sensors and Instrumentation (ASI)
Annual Program Webinar
October 24 – 27, 2022

Federal Program Manager: *Daniel Nichols, PhD*

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

Welcome

The FY22 Advanced Sensors and Instrumentation (ASI) annual program review webinar will run from October 24th – 27th.

The program review contains presentations in the following categories:

12	Directed Research Projects	12	CINR Awards
6	NSUF Awards	7	SBIR/STTR Awards
1	Industry-FOA Award		

Goals:

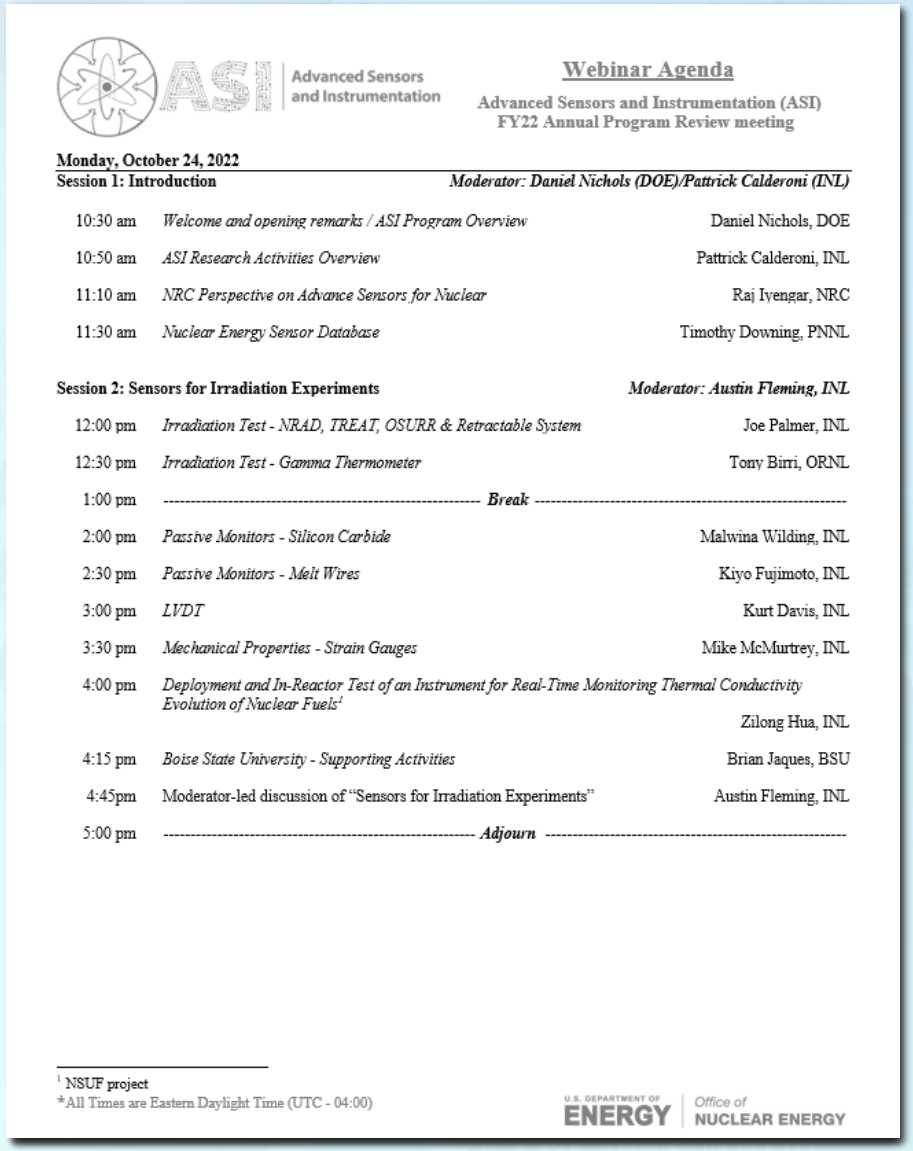
- Complete Annual Review of all ASI program projects
- Provide broad programmatic information for stakeholders throughout NE industry
- Provide detailed project status presentations to inform NE community of progress

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 Eric Schuster:

eric.schuster@inl.gov -or- (208) 526-0465



ASI Advanced Sensors and Instrumentation

Webinar Agenda

Advanced Sensors and Instrumentation (ASI)
FY22 Annual Program Review meeting

Monday, October 24, 2022

Session 1: Introduction — ***Moderator: Daniel Nichols (DOE)/Pattrick Calderoni (INL)***

10:30 am	*Welcome and opening remarks / ASI Program Overview*	Daniel Nichols, DOE
10:50 am	*ASI Research Activities Overview*	Pattrick Calderoni, INL
11:10 am	*NRC Perspective on Advance Sensors for Nuclear*	Raj Iyengar, NRC
11:30 am	*Nuclear Energy Sensor Database*	Timothy Downing, PNNL

Session 2: Sensors for Irradiation Experiments — ***Moderator: Austin Fleming, INL***

12:00 pm	*Irradiation Test - NRAD, TREAT, OSURR & Retractable System*	Joe Palmer, INL
12:30 pm	*Irradiation Test - Gamma Thermometer*	Tony Birri, ORNL
1:00 pm	---------- ***Break*** ----------	
2:00 pm	*Passive Monitors - Silicon Carbide*	Malwina Wilding, INL
2:30 pm	*Passive Monitors - Melt Wires*	Kiyo Fujimoto, INL
3:00 pm	*LVDT*	Kurt Davis, INL
3:30 pm	*Mechanical Properties - Strain Gauges*	Mike McMurtrey, INL
4:00 pm	*Deployment and In-Reactor Test of an Instrument for Real-Time Monitoring Thermal Conductivity Evolution of Nuclear Fuels*[1]	Zilong Hua, INL
4:15 pm	*Boise State University - Supporting Activities*	Brian Jaques, BSU
4:45pm	Moderator-led discussion of "Sensors for Irradiation Experiments"	Austin Fleming, INL
5:00 pm	---------- ***Adjourn*** ----------	

[1] NSUF project
*All Times are Eastern Daylight Time (UTC - 04:00)

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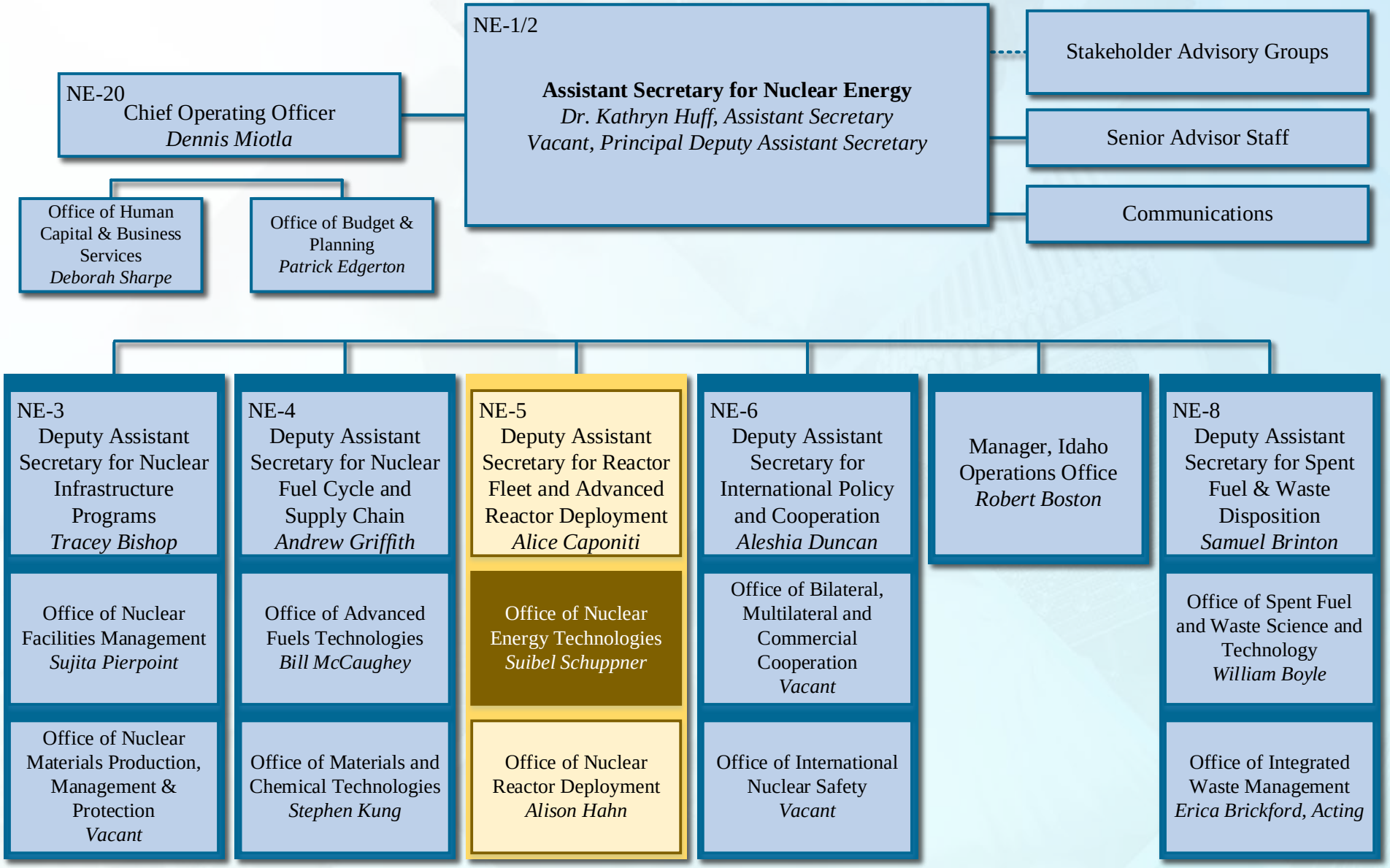
Structure of the Office of Nuclear Energy



Advanced Sensors and Instrumentation Leadership

Federal Program Manager: Daniel Nichols

daniel.nichols@nuclear.energy.gov

National Technical Director: Pattrick Calderoni

pattrick.calderoni@inl.gov

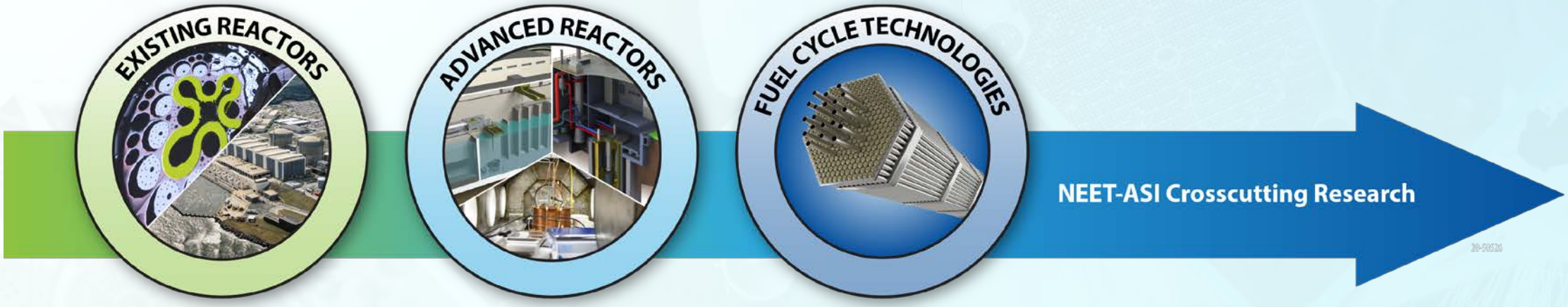
ASI Program Focus

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

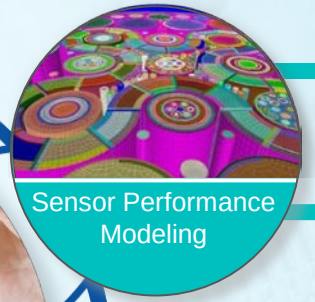
NEET ASI Research results in advanced sensors and I&C technologies that are **qualified, validated, and ready to be adopted by the nuclear industry**



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

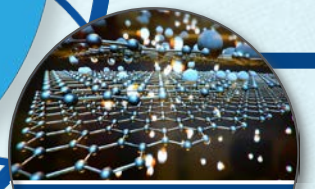
Sensor Performance Modeling

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



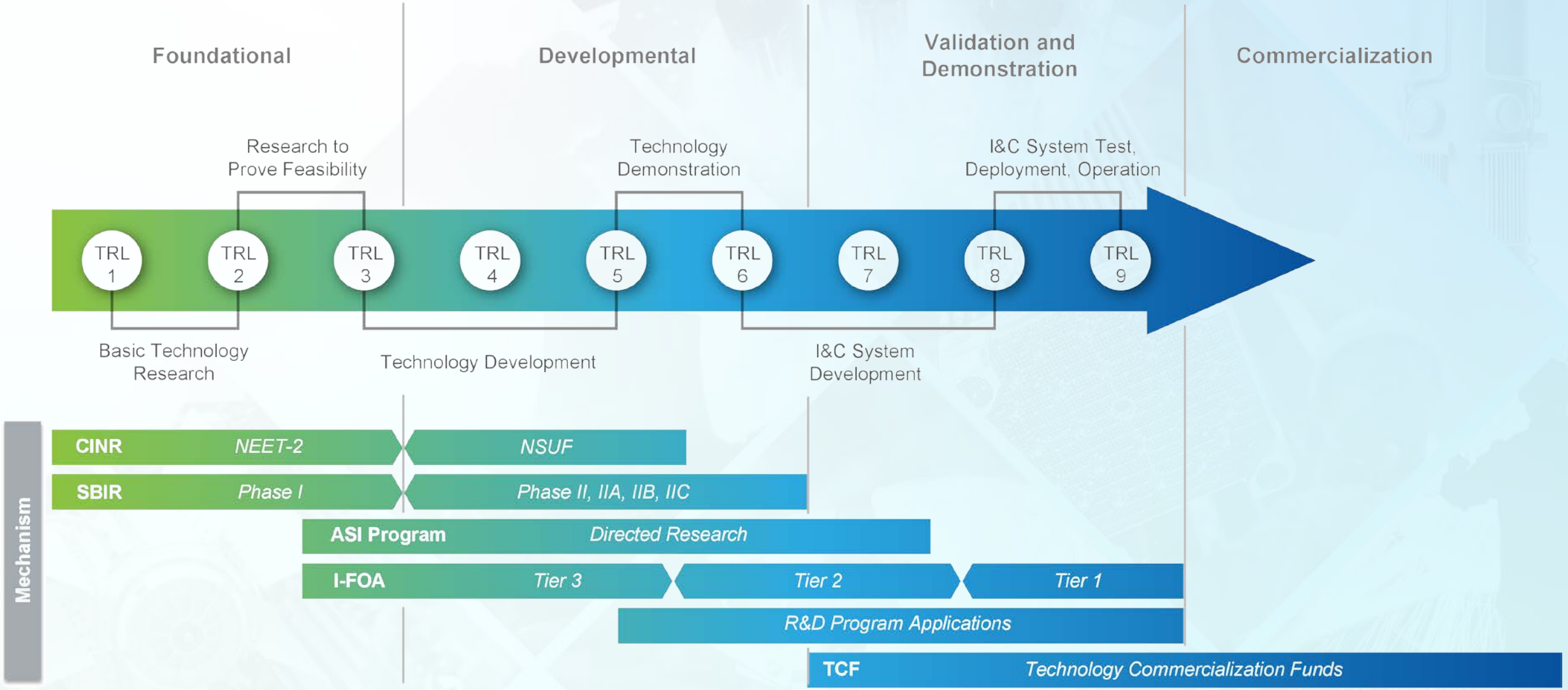
Innovative sensor materials and advanced manufacturing techniques applied to instrumentation design and fabrication

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



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) and 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. 7, 2022
Topic Webinar	Nov. 14, 2022 (tent.)
FOA issued	Dec. 12, 2022
FOA Webinar	Dec. 16, 2022 (tent.)
Letters of Intent	Jan. 3, 2023
Full Applications	Fed. 21, 2023

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/

FY22 SBIR/STTR Recipients (ASI related work)

Subtopic	Phase	Award Type	Insitution	Location	Concluding Fiscal Year	PI	Title
	II	SBIR	Operant Networks Corporation	Santa Rosa, CA	2024	King, Randall	High Penetration Wireless Networking for Nuclear Power Plant Sensing
36q	I	SBIR	X-wave Innovations, Inc.	Gaithersburg, MD	2023	Xiang, Dan	Ultrasonic Multipoint Temperature Sensor for Nuclear Reactor Applications
36q	I	SBIR	Applied Nanotech, Inc.	Austin, TX	2023	Fink, Richard	Printed Sensors for Monitoring Reactor Health
36q	I	STTR	Analysis and Measurement Services Corporation	Knoxville, TN	2023	Hashemian, Alexander	Advanced Process Instrumentation System for Next-Generation Nuclear Reactors
36r	I	SBIR	Vega Wave Systems	West Chicago, IL	2023	Moretti, Tony	Three-Dimensional, Ultra-Radiation-Hardened Video System for Nuclear Power Plant Inspection
36q	I	SBIR	Radiation Detection Technologies, Inc.	Manhattan, KS	2023	Ochs, Taylor	Commercialization of the Micro Pocket Fission Detector (MPFD)
36i	I	STTR	Luna Innovations Incorporated	Roanoke, VA	2023	Boggs, George	Fiber-Optic Multifunctional Sensor for Crack Monitoring in Harsh Environments
36q	I	STTR	Luna Innovations Incorporated	Roanoke, VA	2023	Rountree, Derek	Scaled Reduced Mode Sapphire Fiber Production Towards High Temperature Radiation Resilient Sensors

Other Industry-relevant FOAs

GAIN Gateway for Accelerated Innovation in Nuclear

U.S. Industry Opportunities for Advanced Nuclear Technology Development (DE-FOA-0001817)

- **Current review cycle closed on October 11th, 2022**

Gateway for Accelerated Innovation in Nuclear (GAIN) Vouchers for FY2023:

Round 1 – Applications due Oct. 31, 2022 (5:00pm EDT)

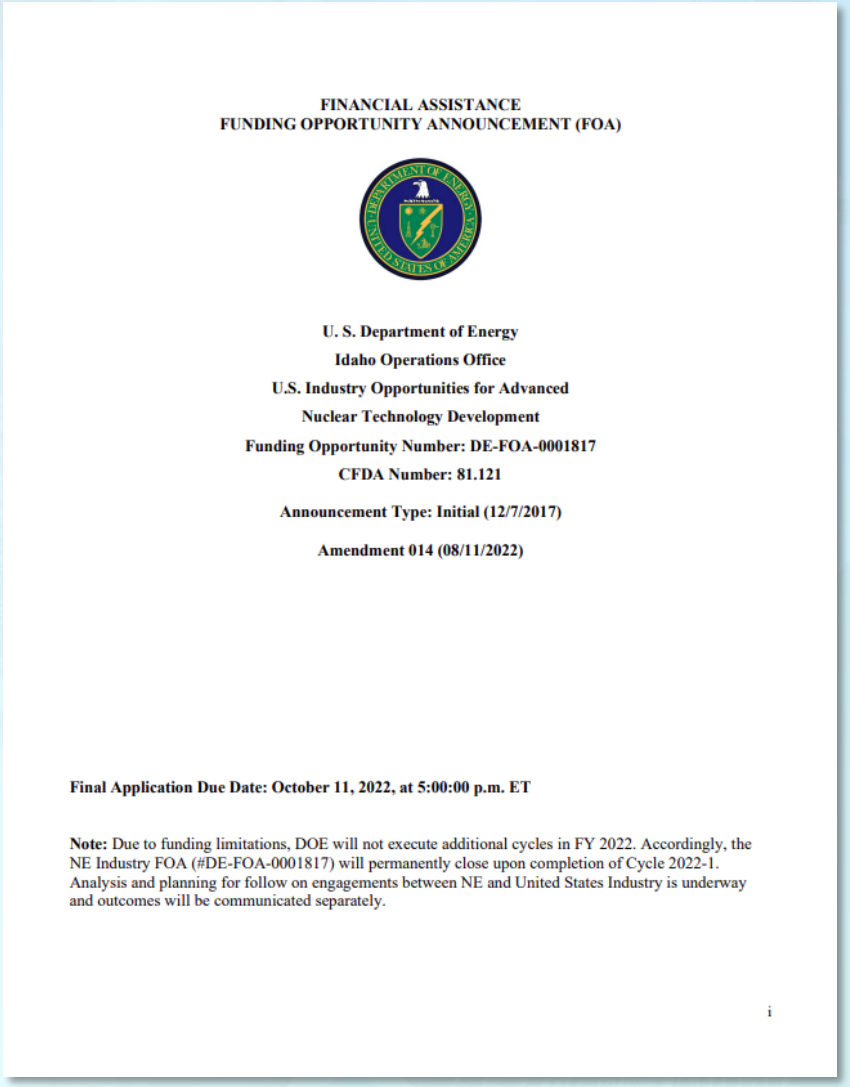
Round 2 – Applications due Jan. 31, 2023 (5:00pm EST)

Round 3 – Applications due May 1, 2023 (5:00pm EDT)

Round 4 – Applications due Jul. 31, 2023 (5:00pm EDT)

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

gain.inl.gov



FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT (FOA)

U. S. Department of Energy
Idaho Operations Office
U.S. Industry Opportunities for Advanced
Nuclear Technology Development
Funding Opportunity Number: DE-FOA-0001817
CFDA Number: 81.121

Announcement Type: Initial (12/7/2017)

Amendment 014 (08/11/2022)

Final Application Due Date: October 11, 2022, at 5:00:00 p.m. ET

Note: Due to funding limitations, DOE will not execute additional cycles in FY 2022. Accordingly, the NE Industry FOA (#DE-FOA-0001817) will permanently close upon completion of Cycle 2022-1. Analysis and planning for follow on engagements between NE and United States Industry is underway and outcomes will be communicated separately.

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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:

NSUF Preliminary Statement of Work
Due Date: November 30, 2022 at 7:00 p.m. ET

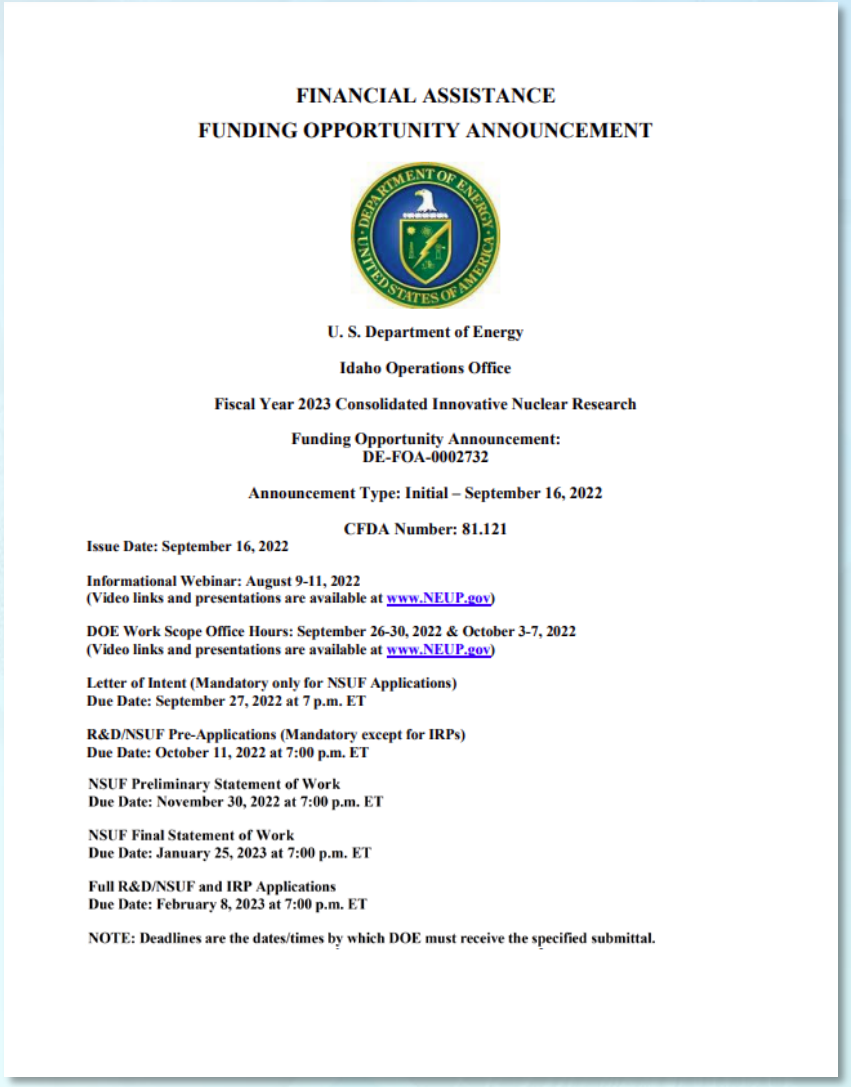
NSUF Final Statement of Work
Due Date: January 25, 2023 at 7:00 p.m. ET

Full R&D/NSUF and IRP Applications
Due Date: February 8, 2023 at 7:00 p.m. ET

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

For more information visit the NEUP website:

neup.inl.gov



FINANCIAL ASSISTANCE

FUNDING OPPORTUNITY ANNOUNCEMENT

U. S. Department of Energy

Idaho Operations Office

Fiscal Year 2023 Consolidated Innovative Nuclear Research

Funding Opportunity Announcement:
DE-FOA-0002732

Announcement Type: Initial – September 16, 2022

CFDA Number: 81.121

Issue Date: September 16, 2022

Informational Webinar: August 9-11, 2022
(Video links and presentations are available at www.NEUP.gov)

DOE Work Scope Office Hours: September 26-30, 2022 & October 3-7, 2022
(Video links and presentations are available at www.NEUP.gov)

Letter of Intent (Mandatory only for NSUF Applications)
Due Date: September 27, 2022 at 7 p.m. ET

R&D/NSUF Pre-Applications (Mandatory except for IRPs)
Due Date: October 11, 2022 at 7:00 p.m. ET

NSUF Preliminary Statement of Work
Due Date: November 30, 2022 at 7:00 p.m. ET

NSUF Final Statement of Work
Due Date: January 25, 2023 at 7:00 p.m. ET

Full R&D/NSUF and IRP Applications
Due Date: February 8, 2023 at 7:00 p.m. ET

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

FY22 CINR Recipient for Workscope CT-5

Project Title: An Innovative Monitoring Technology for the Reactor Vessel of Micro-HTGR

Principal Investigator: Dr. Lesley Wright (Texas A&M University)

Summary: This project will demonstrate the use of existing sensor technology while enhancing the predicting capabilities using computational fluid dynamics (CFD) and machine learning (ML). The team will leverage recent advances in both ML based field reconstruction techniques and diagnostic software to augment traditional sensor capabilities. We will develop and demonstrate an integrated sensor technology for real-time monitoring of thermal-mechanical stresses of the reactor vessel of micro-high temperature gas reactors (mHTGRs). The proposed technology will provide (1) a real-time, reliable and cost-effective monitoring methodology, (2) a quantification of the lifetime and integrity of the pressure vessel of the mHTGR, and (3) a means to improve the economics of the microreactor systems. The team, comprised of experts from academia, industry, and ANL, is well-positioned to develop and demonstrate the monitoring system with expertise in physical measurements, high fidelity numerical simulations, and machine learning.

Project Period: 10/01/2022 – 09/30/2025

TEXAS A&M UNIVERSITY

ASI Program Resources

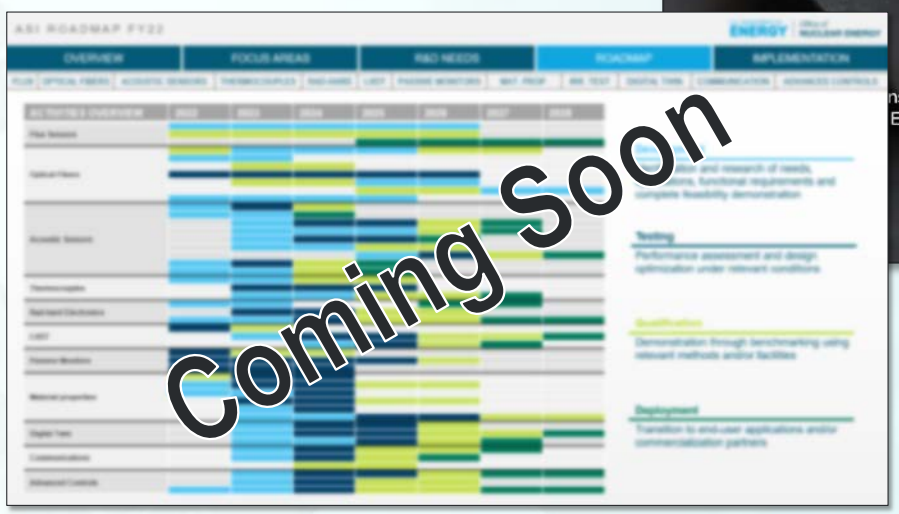
Visit the DOE-NE website:

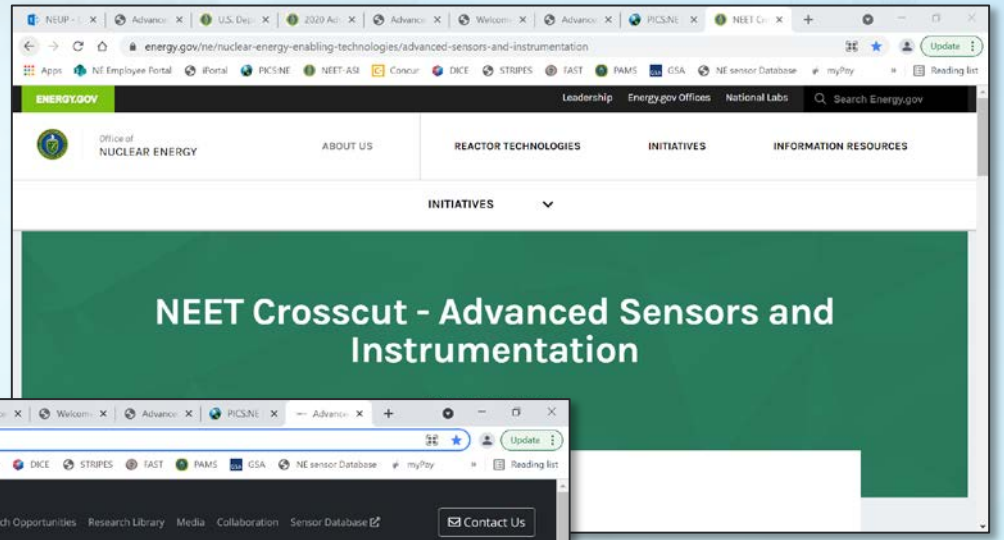
https://www.energy.gov/ne/nuclear-energy-enabling-technologies/advanced-sensors-and-instrumentation

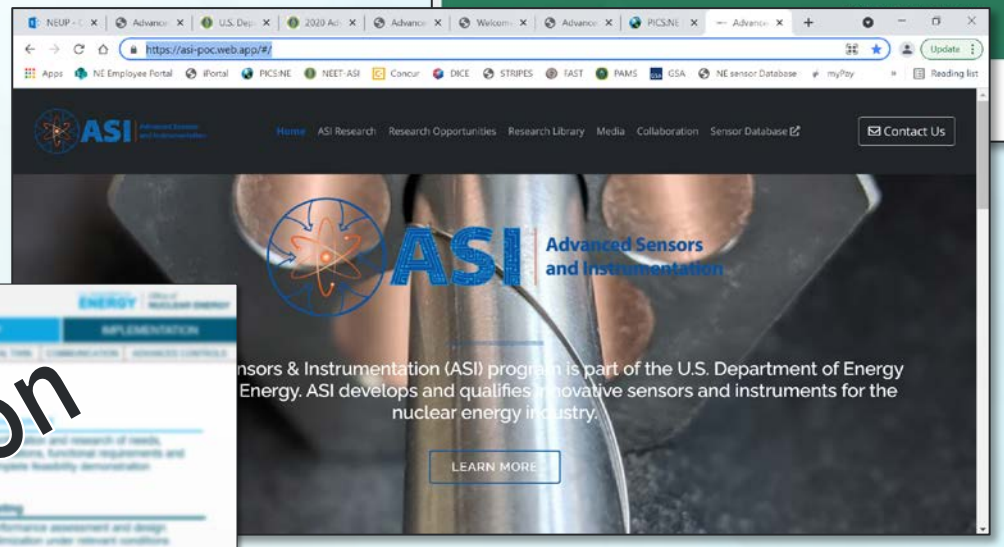
Checkout the new ASI website:

asi.inl.gov

Soon to be released ASI Roadmap:







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

Federal Program Manager | Advanced Sensors and Instrumentation [NE - 51]
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Time Zone: EDT (UTC - 04:00)

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

Thank You

Consolidated Innovative Nuclear Research (CINR)

FY	Project Title	Principal Investigator / Location
2017 (Completed)	Integrated silicon/chalcogenide glass hybrid plasmonic sensor for monitoring of temperature in nuclear facilities	Maria Mitkova / Boise State University
	High temperature embedded/integrated sensors (HiTEIS) for remote monitoring of reactor and fuel cycle systems	Xiaoning Jiang / North Carolina State University
	3-D Chemo-Mechanical Degradation State Monitoring, Diagnostics and Prognostics of Corrosion Processes in Nuclear Power Plant Secondary Piping Structures	Douglas Adams / Vanderbilt University
	Versatile Acoustic and Optical Sensing Platforms for Passive Structural System Monitoring	Gary Pickrell / Virginia Tech
	Ultrasonic Sensors for TREAT Fuel Condition Measurement and Monitoring	Andrew Casella / Pacific Northwestern National Laboratory
2018	Development of optical fiber-based gamma thermometer	Thomas Blue / The Ohio State University
	Analytics-at-scale of Sensor Data for Digital Monitoring in Nuclear Plants	Vivek Agarwal / Idaho National Laboratory
	Process-Constrained Data Analytics for Sensor Assignment and Calibration	Richard Vilim / Argonne National Laboratory
2019	Acousto-optic Smart Multimodal Sensors for Advanced Reactor Monitoring and Control	Michael Larche / Pacific Northwestern National Laboratory
	Design of risk informed autonomous operation for advanced reactor	Michael Golay / Massachusetts Institute of Technology
	Cost-Benefit Analyses through Integrated Online Monitoring and Diagnostics	David Grabaskas / Argonne National Laboratory
	Advanced Online Monitoring and Diagnostic Technologies for Nuclear Plant Management, Operation, and Maintenance	Daniel Cole / University of Pittsburgh
	Context-Aware Safety Information Display for Nuclear Field Workers	George Gibson / Arizona State University
2020	Development of Sensor Performance Model of Microwave Cavity Flow Meter for Advanced Reactor High Temperature Fluids	Alexander Heifetz / Argonne National Laboratory
	Design and Prototyping of Advanced Control Systems for Advanced Reactors Operating in the Future Electric Grid	Roberto Ponciroli / Argonne National Laboratory
2021	Gallium Nitride-based 100-Mrad Electronics Technology for Advanced Nuclear Reactor Wireless Communications	Milton Ericson / Oak Ridge National Laboratory

FY	Project Title	Principal Investigator / Location
2017 (Completed)	Additive manufacturing of thermal sensors for in-pile thermal conductivity measurement	David Estrada / Boise State University
	Radiation Effects on Optical Fiber Sensor Fused Smart Alloy Parts with Graded Alloy Composition Manufactured by Additive Manufacturing Processes	Kevin Chen / University of Pittsburgh
2018	Irradiation Behavior of Piezoelectric Materials for Nuclear Reactor Sensors	Marat Khafizov / The Ohio State University
	High-performance nanostructured thermoelectric materials and generators for in-pile power harvesting	Yanliang Zhang / University of Notre Dame
2019	Irradiation of Optical Components of In-Situ Laser Spectroscopic Sensors for Advanced Nuclear Reactor Systems	Igor Jovanovic / University of Michigan
	High Fluence Active Irradiation and Combined Effects Testing of Sapphire Optical Fiber Distributed Temperature Sensors	Joshua Daw / Idaho National Laboratory
2020	Irradiation of Sensors and Adhesive Couplants for Application in LWR Primary Loop Piping and Components	James Wall / Electric Power Research Institute
2021	Understanding irradiation behaviors of ultrawide bandgap Ga2O3 high temperature sensor materials for advanced nuclear reactor systems	Ge yang / North Carolina State University
	Deployment and In-Pile Test of an Instrument for Real-Time Monitoring Thermal Conductivity Evolution of Nuclear Fuels	Zilong Hua / Idaho National Laboratory

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

Phase	FY	Project Title	Principal Investigator / Location
II B	2019	High Temperature Operable, Harsh Environment Tolerant Flow Sensors For Nuclear Reactor Applications	Jon Lubbers / Sporian Microsystems, Inc.,
II		Metamaterial Void Sensor for Fast Transient Testing	Mark Roberson / Goldfinch Sensor Technologies and Analytics LLC
II		Health Monitoring of Digital I&C Systems using Online Electromagnetic Measurements	Chad Kiger / Analysis & Measurement Services Corp.
II		Fault Detection of Digital Instrumentation and Control Systems using Integrated Electromagnetic Compatibility and Automated Functional Testing	Greg Morton / Analysis & Measurement Services Corp.
II	2020	Video Camera for Harsh Environments in Nuclear	Esen Salcin / Alphacore Inc
II		Development of Radiation Endurance Ultrasonic Transducer for Nuclear Reactors	Uday Singh / X-wave Innovations, Inc.
II		Advanced Laser Ultrasonic Sensor for Fuel Rod Characterization	Marvin Klein / Intelligent Optical Systems, Inc.
I	2021	Integration of Wireless Sensor Networks and Battery-free RFID for Advanced Reactors	Faranak Nekoogar / Dirac Solutions Inc.
I		High Penetration Wireless Networking for Nuclear Power Plant Sensing	Randall King / Operant Networks Corporation

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

FY	Industry-FOA Project Title	Recipient
2019	Machine Learning for Enhanced Diagnostic and Prognostic Capabilities of NPP Assets	Blue Wave AI Labs, Inc.
	Passive Radio Frequency Tags and Sensors for Process Monitoring in Advanced Reactors	Dirac Solutions Inc.

FY	GAIN Voucher Title	Recipient / Location
2017	Radiation Aging of Nuclear Power Plant Components	Analysis and Measurement Services Corp / Knoxville, TN
	Human Factors Engineering for the Move to Digital Control Systems – Improved Strategies for Operations	GSE Systems Inc / Sykesville, MD
2018	Advancement of Instrumentation to Monitor IMSR® Core Temperature and Power Level	Terrestrial Energy USA / New York, NY
	Electroanalytical Sensors for Liquid Fueled Fluoride Molten Salt Reactor	ThorCon / Stevenson, WA
2019	Testing of Instrumentation and Control Sensors and Cables for Small Modular Reactors	Analysis & Measurement Services Corp. / Knoxville, TN
2020	On-Line Lead/Water Heat Exchanger Sensor/System Feasibility	Hydromine, Inc. / New York, NY
2021	Radiation Testing for High-Resolution, Radiation-Hardened Camera Systems	Vega Wave Systems, Inc / West Chicago, IL