



Advanced Sensors and Instrumentation Program Overview

Suibel Schuppner, Program Manager
Office of Nuclear Energy, U.S. Department of Energy
October 31, 2018

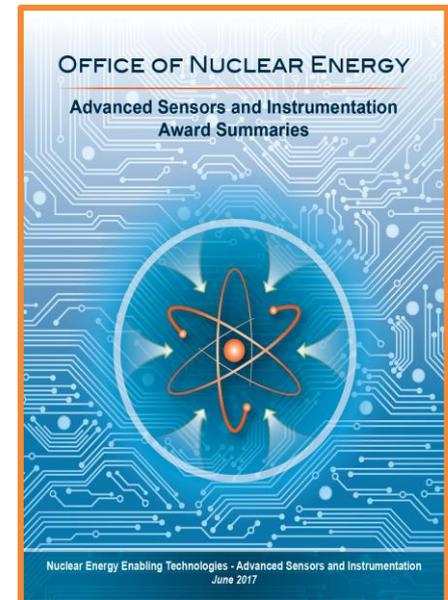
Nuclear Energy Enabling Technologies: Advanced Sensors and Instrumentation

Vision

Develop advanced sensors and instrumentation technologies that address critical technology gaps for monitoring and controlling advanced reactors and fuel cycle facilities

Goals

- Support DOE-NE R&D programmatic needs
 - Fuel & material studies, integral tests
- Provide new capabilities for measurement and control
 - Sensors for harsh environments, advanced control capabilities, fault tolerant operations
- Address R&D needs for successful deployment
 - Digital technology qualification, advanced operational concepts



www.energy.gov/ne

NE Mission Strategic Linkage

ASI Supports NE Priority Mission Elements:

- **New & Innovative Sensor Capability**
- **Enhanced Monitoring and Control System**
- **Greater Data Generation and Transmission**
- **Advanced Concepts of Operation**

Existing Fleet



Advanced
Reactor
Pipeline



Fuel Cycle
Infrastructure



FY 2019 Consolidated Innovative Nuclear Research (CINR) Funding Opportunity Announcement (FOA)

- **University-led R&D** [Nuclear Energy University Programs (NEUP)]
 - Program and Mission Supporting
- **Industry-, University-, or National Laboratory-led R&D** [Nuclear Energy Enabling Technologies (NEET) Program]
 - Advanced Sensors and Instrumentation
 - Advanced Methods for Manufacturing
 - At least 20% cost share for industry leads
- **University-led, Program Directed Integrated Research Projects [NEUP]**
 - Program Directed work
- **CINR Due dates:**
 - September 24, 2018: NSUF Letter of Intent
 - October 11, 2018: R&D/NSUF Pre-Applications
 - November 15, 2018: Infrastructure Applications
 - February 12, 2019: Full R&D Applications
 - February 12, 2019: IRP Applications



www.neup.gov

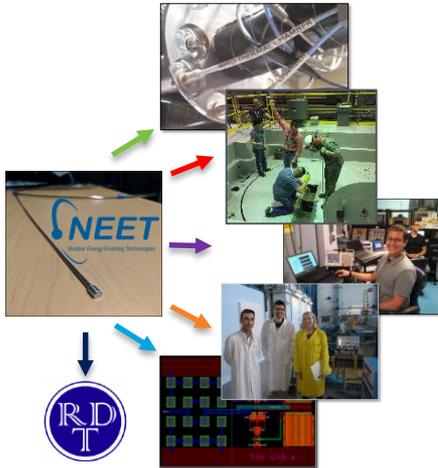
NEET-ASI Current Awards

FY	Project Title	Principal Investigator
2015	Nuclear Qualification Demonstration of a Cost Effective Common Cause Failure Mitigation in Embedded Digital Devices	Matt Gibson, Electric Power Research Institute
2015	Development and Demonstration of a Model Based Assessment Process for Qualification of Embedded Digital Devices in Nuclear Power Applications	Richard Wood, University of Tennessee
2016	Transmission of Information by Acoustic Communication along Metal Pathways in Nuclear Facilities	Richard Vilim, Argonne National Laboratory
2016	Wireless Reactor Power Distribution Measurement System Utilizing an In-Core Radiation and Temperature Tolerant Wireless Transmitter and a Gamma-Harvesting Power Supply	Jorge Carvajal, Westinghouse Electric Company
2016	Self-powered Wireless Through-wall Data Communication for Nuclear Environments	Lei Zuo, Virginia Tech
2017	Integrated silicon/chalcogenide glass hybrid plasmonic sensor for monitoring of temperature in nuclear facilities	Maria Mitkova, Boise State University
2017	High temperature embedded/integrated sensors (HiTEIS) for remote monitoring of reactor and fuel cycle systems	Xiaoning Jiang, North Carolina State University
2017	3-D Chemo-Mechanical Degradation State Monitoring, Diagnostics and Prognostics of Corrosion Processes in Nuclear Power Plant Secondary Piping Structures	Douglas Adams, Vanderbilt University
2017	Versatile Acoustic and Optical Sensing Platforms for Passive Structural System Monitoring	Gary Pickrell, Virginia Polytechnic Institute and State University
2018	Process-Constrained Data Analytics for Sensor Assignment and Calibration	Richard Vilim, Argonne National Laboratory
2018	Analytics-at-scale of Sensor Data for Digital Monitoring in Nuclear Plants	Vivek Agarwal - INL
2018	Development of optical fiber based gamma thermometer and its demonstration in a University Research Reactor using statistical data analytic methods to infer power distributions from gamma thermometer response	Thomas Blue, The Ohio State

NEET ASI: Matures early stage crosscutting technology for deployment and commercialization

Micro Pocket Fission Detector :

- ATR irradiations: AGR 5/6/7, ATF-2
- TREAT irradiations: OSU IRP, MIMIC
- University irradiations: MIT, UW, KSU, ISU
- CEA MINERVE irradiation characterization
- US-ROK INERI collaborative project
- DOE-NE SBIR, RDT Phase I award



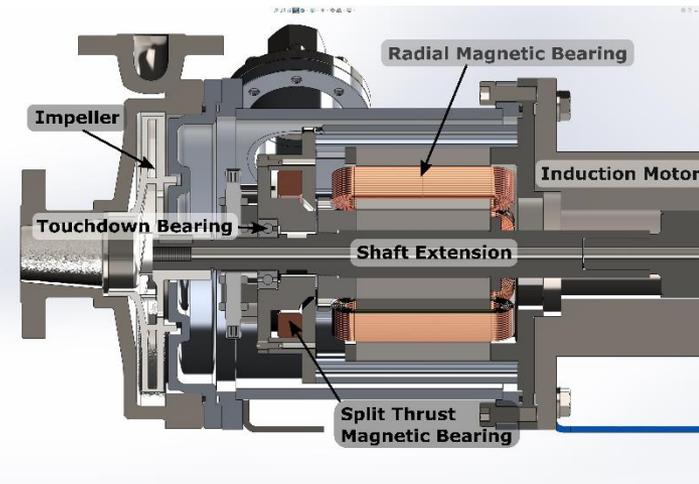
Operator Support Technologies for Fault Tolerance and Resilience:

- Working with a U.S. utility to automate monitoring of high pressure feed water system.
- Part of larger industry goal of maintenance optimization and asset management.
- Awarded under Technology Commercialization Fund.



Demonstration of Embedded I&C:

- ARPA-E award to build and test an operation 650 C canned rotor pump with a stretch goal of 700 C over the next 2.5 years.
- ORNL partnered with industry: Hayward Tyler and TEUSA.
- The high temperature canned rotor pump would allow Hayward Tyler to break into the nuclear and solar industries market.



Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STT) : Advanced Technologies for Nuclear Energy

- Competitive awards for small businesses only
- Winners keep the rights to any technology developed and are encouraged to commercialize the technology
- Funded by federal R&D budgets set aside

NE funds SBIR and STTR projects

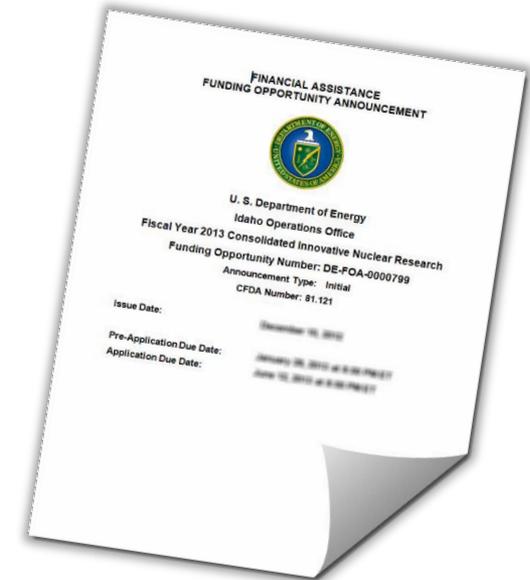
- Office of Nuclear Energy Section

Phase I Release 2

- Topics Issued: October 29, 2018
- Webinar: November 07, 2018
- FOA Issued: November 26, 2018
- LOI Due: December 17, 2018
- Application Due: February 04, 2019

Phase I Release 2 (only Phase I awardees are eligible to apply)

- FOA Issued: March 4, 2019
- LOI Due: April 1, 2019
- Application Due: April 23, 2019



www.science.energy.gov/sbir

SBIR Current Awards

FY	Project Title	Principal Investigator
	PHASE II	
2016	High Temperature Operable, Harsh Environment Tolerant Flow Sensors For Nuclear Reactor Applications	Jon Lubbers, Sporian Microsystems, Inc
2017	A robust wireless communication system for harsh environment including nuclear facilities	Richard Twogood, Dirac Solutions Inc
2018	Distributed Antenna System for Wireless Data Communication in Nuclear Power Plants	Chad Kiger, Analysis & Measurement Serv Corp
2018	Fiber-Optic Sensor for Simultaneous Measurement of Temperature and Pressure	Derek Rountree, Luna Innovations Inc
	PHASE I	
2018	Metamaterial void sensor for fast transient testing	Mark Roberson, Goldfinch Sensor Technologies and Analytics LLC
2018	Gamma-Heated In-Core Thermoacoustic Sensor	David Brown, BTech Acoustics LLC
2018	Intelligent III-V GaN based neutron flux detector array	Vasil Hlinka, AwareAbility Technologies LLC
2018	Process-Constrained Data Analytics for Sensor Assignment and Calibration	Chad Kiger, Analysis & Measurement Serv Corp
2018	Fault Detection of Digital Instrumentation and Control Systems using Integrated Electromagnetic Compatibility and Automated Functional Testing	Greg Morton, Analysis & Measurement Serv Corp

SBIR Projects Success Stories

- **Advanced Diagnostics for the Control Element Drive Mechanism System in Pressurized Water Reactors**
 - already installed in a commercial NPP in the United States, and is being used on a routine basis.
 - Diagnosed an impending CEDM coil failure and prevented an unplanned forced outage.
- **Strategy for Implementation of Fixed and Mobile Wireless Technologies in Crowded and Confined EMI Environments of Nuclear Power Plants**
 - Commercialized at two different utilities to demonstrate that existing plant equipment is immune to wireless signals.
- **Robust Wireless Communication System for Harsh Environments Including Nuclear Facilities**
 - Further funded by other DOE and DOD offices for data transmissions in hostile RF environments.
 - developing a UWB wireless communications systems for real-time transmission of images from IAEA's safeguards cameras in various nuclear facilities.



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

- The U.S. Department of Energy (DOE) is soliciting proposals for cost-shared projects to develop innovative industry-driven reactor designs and technologies to advance nuclear power in America.
- This funding opportunity is open for a five-year period.
- Applications will be accepted on a year-round basis with selections announced every quarter.
- Open to U.S. companies with the expectation that resulting products will be manufactured in U.S. after reaching commercialized state.
- Industry cost share will be between 20-50%, depending on the nature of the proposal

Pathway	DOE Funding Range	Cost Share	Duration
First-of-a-Kind (FOAK) Nuclear Demonstration Readiness Projects	\$10M-\$40M	50/50	3 years
Advanced Reactor Development Projects	\$500K-\$10M	80/20	2 years
Regulatory Assistance Grants	\$50K-\$500K	80/20 or 50/50	1 year

<https://www.energy.gov/ne/services/funding-opportunities>

Gateway for Accelerated Innovation in Nuclear (GAIN) Vouchers

- Provide funds to assist industry applicants seeking access to world class expertise and capabilities available across the U.S. DOE Complex.

Industry I&C Current Awards

FY	Voucher Title	Recipient
2017	Radiation Aging of Nuclear Power Plant Components	Analysis & Measurement Serv Corp Knoxville, TN
2017	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
2018	Electroanalytical Sensors for Liquid Fueled Fluoride Molten Salt Reactor	ThorCon, Stevenson, WA

FY	Regulatory Assistance Grant Title	Recipient
2018	Resolving the Regulatory Issues with Implementation of Online Monitoring Technologies to Extend the Calibration Intervals of Process Instruments in Nuclear Power Plants	Analysis & Measurement Serv Corp Knoxville, TN

FY18 In-Pile Instrumentation Program

Mission: Establish baseline instrumentation and novel sensors and measurement systems for in-pile applications that can provide real-time, accurate, spatially resolved information regarding test conditions and the performance of fuels and materials during irradiation

Goals:

- Conduct R&D to advance instrumentation's Technology Readiness Level (TRL):
 1. Baseline capability (TRL 5-6 / technology demonstration)
 2. Innovative sensors (TRL 3-4 / technology development)
 3. Integrated measurement systems (TRL 2-6 / feasibility, technology development, and demonstration)
- Focus on irradiation testing conducted at material test reactor facilities including the Advanced Test Reactor, Transient Test Reactor Test facility, High Flux Isotope Reactor, and Massachusetts Institute of Technology Reactor



FY18 Digital Environment for Advanced Reactors Workshop

Digital Environment for Advanced Reactors Workshop (June 5th & 6th)

- DOE-NE sponsored workshop, partnering with GAIN, EPRI, and NEI
- Nuclear industry input related to advanced sensors, monitoring, control and human automation interaction technologies needed to support the deployment of advanced reactors.
- Forum for exchange of information about ongoing I&C research and development for the next generation of nuclear plants

Results

- Help inform DOE research planning, including planned solicitations, cost shared research and development, and pilot projects through private-public partnerships
- Enable continued communication with Advanced Reactors Community through GAIN, including additional workshops on targeted focused I&C areas of interest

Digital Environment for Advanced Reactors Workshop

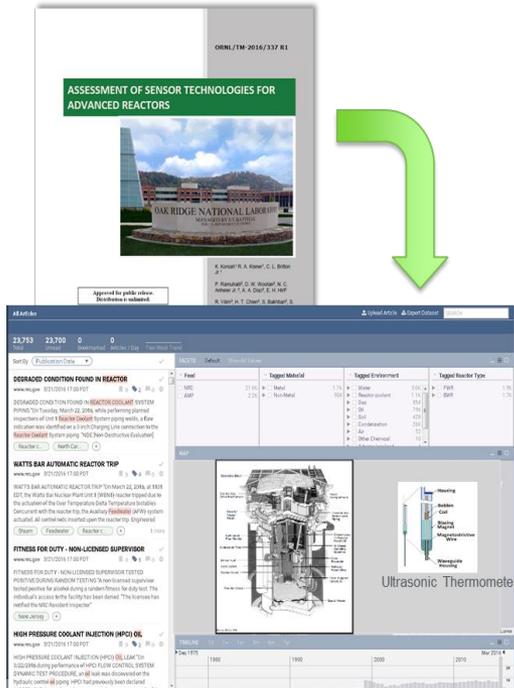
Argonne National Laboratory, Chicago, IL • June 5-6, 2018



More Info at - <https://gain.inl.gov/SitePages/Workshops.aspx>

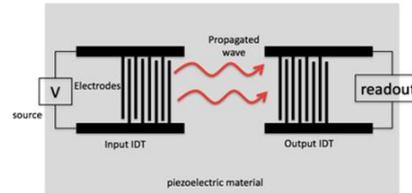
FY19 New Activities

Sensor Technology Assessment Database



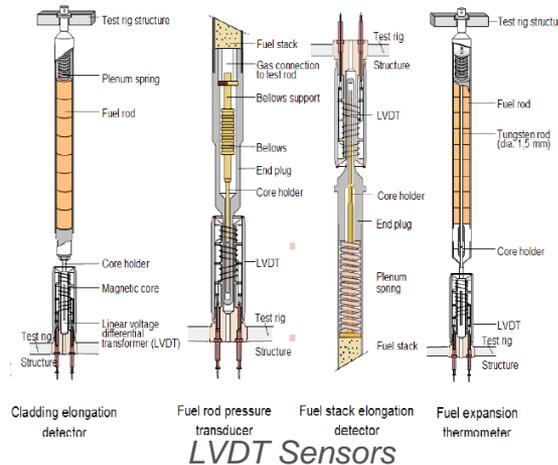
Develop and maintain a searchable online repository of advanced sensor and instrumentation technology, applicable to nuclear power plants

Direct Digital Printing of Sensors for Nuclear Energy Applications



Develop and demonstrate a prototype passive wireless sensor network deployed at a NPP facility. This network will include surface acoustic wave (SAW) sensors, or other printed electronic devices as needed for measurement of voltage, current, and hydrogen.

In-Pile Instrumentation Development to mitigate the loss of capability caused by the closure of the Halden Reactor



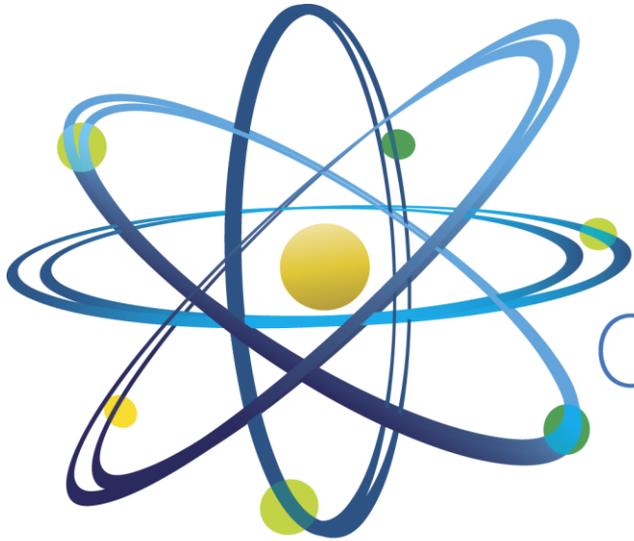
Provide instrumentation development and deployment for material test reactor experiments at ATR and other MTRs

Summary

- 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.

I&C technologies are a vital key to enabling the expansion of clean, safe, and economical nuclear power

Questions?



Clean. **Reliable. Nuclear.**