Advanced Sensors and Instrumentation
Program Overview
October 29, 2020

Suibel Schuppner
Office of Nuclear Energy
U.S. Department of Energy
Reactors Fleet and Advanced Reactor Deployment (NE-5)

- Advanced Sensors and Instrumentation (ASI)
- Advanced Methods for Manufacturing (AMM)
- Nuclear Energy Advanced Modeling and Simulation (NEAMS)
- Nuclear Science User Facilities (NSUF)
- Transformational Challenge Reactor (TCR)

- Nuclear Energy University Program (NEUP)
- Integrated University Program (IUP)
- Research Reactor Infrastructure (RRI)
- Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)
- Gateway for Accelerated Innovation in Nuclear (GAIN)
- Advanced Nuclear Industry Funding Opportunity (Industry FOA)
- Technology Commercialization Fund (TCF)

- Light Water Reactor Sustainability (LWRS)
- Advanced Small Modular Reactor R&D
- Integrated Energy Systems (IES)
- Nuclear Cybersecurity
- Advanced Reactors Safeguards (ARS)

- Sodium-Cooled Fast Reactor
- Gas-Cooled High-Temperature Reactors
- Molten Salt Reactors
- Microreactors
- National Reactor Innovation Center (NRIC)
- Risk Reduction
- Advanced Reactor Regulatory Development
New Advanced Sensors and Instrumentations Management

Federal Program Manager: Melissa Bates
Melissa.bates@nuclear.energy.gov

National Technical Director: Pattrick Calderoni
pattrick.calderoni@inl.gov
**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.
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.

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

Big Data, Machine Learning, Artificial Intelligence
Machine learning and artificial intelligence processes to enable semi-autonomous operation and maintenance by design.

Advanced Control Systems
Enable near real-time control of plant or experiments process variables to enhance performance.
Metrics: ASI Research Progression

Foundational
- TRL 1
- Basic Technology Research
- Research to Prove Feasibility

Developmental
- TRL 2
- Technology Development
- TRL 3
- TRL 4
- TRL 5
- TRL 6
- Technology Demonstration

Validation and Demonstration
- I&C System Test, Deployment, Operation
- TRL 7
- TRL 8
- TRL 9

Commercialization
- Technology Commercialization Funds

Mechanism
- CINR
- NEET-2
- NSUF-1.1
- Phase I
- Phase II
- ASI Directed Research Activities
- Pathway 3
- Pathway 2
- Pathway 1
- I-FOA
- R&D Programs Applications
- Technology Commercialization Funds
NE Funding Opportunities

• **Consolidated Innovative Nuclear Research (CINR)**
  – Nuclear Energy University Program (NEUP)
  – Nuclear Energy Enabling Technologies (NEET)
  – Nuclear Science User Facilities (NSUF)

• **Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)**
  – Advanced Technologies for Nuclear Energy
  – Phase I Release 2

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

• **Gateway for Accelerated Innovation in Nuclear (GAIN) Vouchers**

https://gain.inl.gov
FY2020 Consolidated Innovative Nuclear Research (CINR) Funding Opportunity Announcement (FOA)

• University-led Nuclear Energy University Programs (NEUP) Projects
  • Program and Mission Supporting

• University-, or National Laboratory-led Nuclear Energy Enabling Technologies (NEET) Crosscutting Projects
  • Advanced Sensors and Instrumentation
  • Advanced Methods for Manufacturing

• University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF)
  • NSUF-1.1: Testing of advanced materials for sensors and advanced sensors for Nuclear applications

• CINR Due dates:
  • September 16, 2020: NSUF Letter of Intent
  • September 30, 2020: R&D/NSUF Pre-Applications
  • November 12, 2020: NSUF Preliminary Statement of Work
  • January 22, 2021: NSUF Final Statement of Work
  • February 11, 2021: Full R&D Applications
  • February 11, 2021: IRP Applications

www.neup.gov
<table>
<thead>
<tr>
<th>FY</th>
<th>Project Title</th>
<th>Principal Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Integrated silicon/chalcogenide glass hybrid plasmonic sensor for monitoring of temperature in nuclear facilities</td>
<td>Maria Mitkova, Boise State University</td>
</tr>
<tr>
<td>2017</td>
<td>High temperature embedded/integrated sensors (HiTEIS) for remote monitoring of reactor and fuel cycle systems</td>
<td>Xiaoning Jiang, North Carolina State University</td>
</tr>
<tr>
<td>2017</td>
<td>Versatile Acoustic and Optical Sensing Platforms for Passive Structural System Monitoring</td>
<td>Gary Pickrell, Virginia Polytechnic Institute and State University</td>
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<tr>
<td></td>
<td>Process-Constrained Data Analytics for Sensor Assignment and Calibration</td>
<td>Richard Vilim, Argonne National Laboratory</td>
</tr>
<tr>
<td>2018</td>
<td>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</td>
<td>Thomas Blue, The Ohio State</td>
</tr>
<tr>
<td></td>
<td>Design of Risk Informed Autonomous Operation for Advanced Reactor</td>
<td>Michael Golay, Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>2019</td>
<td>Cost-Benefit Analyses through Integrated Online Monitoring and Diagnostics</td>
<td>David Grabaskas, Argonne National Laboratory</td>
</tr>
<tr>
<td>2019</td>
<td>Acousto-optic Smart Multimodal Sensors for Advanced Reactor Monitoring and Control</td>
<td>Michael Larche, Pacific Northwest National Laboratory</td>
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<tr>
<td>2019</td>
<td>Context-Aware Smart Information Display for Nuclear Field Worker</td>
<td>Pingbo Tang, Arizona State University</td>
</tr>
<tr>
<td>2019</td>
<td>Advanced Online Monitoring and Diagnostic Technologies for Nuclear Plant Management Operation, and Maintenance</td>
<td>Daniel Cole, University of Pittsburgh</td>
</tr>
<tr>
<td>2020</td>
<td>Adaptive Control and Monitoring Platform for Autonomous Operation of Advanced Nuclear Reactors</td>
<td>Athi Varutthamaseni, Brookhaven National Laboratory</td>
</tr>
<tr>
<td>2020</td>
<td>Development of Sensor Performance Model of Microwave Cavity Flow Meter for Advanced Reactor High Temperature Fluids</td>
<td>Alexander Heifetz, Argonne National Laboratory</td>
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<tr>
<td>2018</td>
<td>Irradiation Behavior of Piezoelectric Materials for Nuclear Reactor Sensors</td>
<td>Marat Khafizov, Ohio State University</td>
</tr>
<tr>
<td>2018</td>
<td>High-performance nanostructured thermoelectric materials and generators for in-pile power harvesting</td>
<td>Yianliang Zhang, University of Notre Dame</td>
</tr>
<tr>
<td>2019</td>
<td>Irradiation of optical components of in-situ laser spectroscopic sensors</td>
<td>Igor Ivanovic, University of Michigan</td>
</tr>
<tr>
<td>2019</td>
<td>High Fluence Active Irradiation and Combined Effects Testing of Sapphire Optical Fiber Distributed Temperature Sensors</td>
<td>Josh Daw, Idaho National Laboratory</td>
</tr>
<tr>
<td>2020</td>
<td>Irradiation of Sensors and Adhesive Couplants for Application in LWR Primary Loop Piping and Components</td>
<td>James Wall, EPRI</td>
</tr>
</tbody>
</table>
• 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: November 09, 2020
• Webinar: November 16, 2020
• FOA Issued: December 14, 2020
• LOI Due: January 2, 2021
• Application Due: February 22, 2021

Phase II Release 2 (only Phase I awardees are eligible to apply)
• FOA Issued: March 01, 2021
• LOI Due: March 31, 2021
• Application Due: April 20, 2021
## SBIR Current Awards

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<thead>
<tr>
<th>FY</th>
<th>Project Title</th>
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<tbody>
<tr>
<td>2017</td>
<td>A robust wireless communication system for harsh environment including nuclear facilities</td>
<td>Richard Twogood, Dirac Solutions Inc</td>
</tr>
<tr>
<td>2018</td>
<td>Distributed Antenna System for Wireless Data Communication in Nuclear Power Plants</td>
<td>Chad Kiger, Analysis &amp; Measurement Serv Corp</td>
</tr>
<tr>
<td>2018</td>
<td>Fiber-Optic Sensor for Simultaneous Measurement of Temperature and Pressure</td>
<td>Derek Rountree, Luna Innovations Inc</td>
</tr>
<tr>
<td>2019</td>
<td>Metamaterial Void Sensor for FastTransient Testing</td>
<td>Mark Roberson, Goldfinch Sensor Technologies and Analytics LLC</td>
</tr>
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<td>2019</td>
<td>Health Monitoring of Digital I&amp;C Systems using Online Electromagnetic Measurements</td>
<td>Chad Kiger, Analysis &amp; Measurement Serv Corp</td>
</tr>
<tr>
<td>2020</td>
<td>Development of Radiation Endurance Ultrasonic Transducer for Nuclear Reactors</td>
<td>Uday Singh, X-wave Innovations Inc</td>
</tr>
<tr>
<td>2020</td>
<td>A Radiation and Temperature-Tolerant Plasma Contact Microphone for Sensing Ultrasonic Acoustic Emissions in Fatiguing Metal Structures</td>
<td>Johan Carlsson, RadiaSoft LLC</td>
</tr>
<tr>
<td></td>
<td><strong>PHASE I</strong></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>Printed Sensors for Monitoring Reactor Health</td>
<td>Richard Fink, Applied Nanotech, Inc</td>
</tr>
<tr>
<td>2020</td>
<td>Hybrid Diamond Detector for Nuclear Reactor Monitoring</td>
<td>Valerly Konovalov, Applied Diamond, Inc</td>
</tr>
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</table>
U.S. Industry Opportunities for Advanced Nuclear Technology Development (DE-FOA-0001817) Amendment 008 (Sep. 2020)

- 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 made twice a year.
  - Due Date: February 28 at 5:00:00 p.m. ET
  - Due Date: August 31 at 5:00:00 p.m. ET
- 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

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
  - Due Date: November 2 at 5:00:00 p.m. ET

<table>
<thead>
<tr>
<th>Pathway</th>
<th>DOE Funding Range</th>
<th>Cost Share</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-of-a-Kind (FOAK) Nuclear Demonstration Readiness Projects</td>
<td>$10M-$40M</td>
<td>50/50</td>
<td>3 years</td>
</tr>
<tr>
<td>Advanced Reactor Development Projects</td>
<td>$500K-$10M</td>
<td>80/20</td>
<td>2 years</td>
</tr>
<tr>
<td>Regulatory Assistance Grants</td>
<td>$50K-$500K</td>
<td>80/20 or 50/50</td>
<td>1 year</td>
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https://gain.inl.gov
### Industry I&C Current Awards

#### GAIN Voucher Title

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<thead>
<tr>
<th>FY</th>
<th>Industry-FOA Project Title</th>
<th>Recipient</th>
</tr>
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<tr>
<td>2017</td>
<td>Radiation Aging of Nuclear Power Plant Components</td>
<td>Analysis &amp; Measurement Services Corp. Knoxville, TN</td>
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<tr>
<td>2017</td>
<td>Human Factors Engineering for the Move to Digital Control Systems – Improved Strategies for Operations</td>
<td>GSE Systems Inc. Sykesville, MD</td>
</tr>
<tr>
<td>2018</td>
<td>Advancement of Instrumentation to Monitor IMSR® Core Temperature and Power Level</td>
<td>Terrestrial Energy USA New York, NY</td>
</tr>
<tr>
<td>2018</td>
<td>Electroanalytical Sensors for Liquid Fueled Fluoride Molten Salt Reactor</td>
<td>ThorCon, Stevenson, WA</td>
</tr>
<tr>
<td>2019</td>
<td>Testing of Instrumentation and Control Sensors and Cables for Small Modular Reactors</td>
<td>Analysis &amp; Measurement Services Corp. Knoxville, TN</td>
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<tr>
<td>2018</td>
<td>Resolving the Regulatory Issues with Implementation of Online Monitoring Technologies to Extend the Calibration Intervals of Process Instruments in Nuclear Power Plants</td>
<td>Analysis &amp; Measurement Services Corp. Knoxville, TN</td>
</tr>
<tr>
<td>2019</td>
<td>Application of Machine Learning for Enhanced Diagnostic and Prognostic Capabilities of Nuclear Power Plant Assets</td>
<td>Blue Wave Capital and Consulting, DBA Blue Wave AI Labs, Celebration, FL</td>
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<td>2018</td>
<td>Resolving the Regulatory Issues with Implementation of Online Monitoring Technologies to Extend the Calibration Intervals of Process Instruments in Nuclear Power Plants</td>
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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 and directed work

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