DNN TECH LANGUAGE GUIDE

Initialisms
NNSA: National Nuclear Security Administration
DOE: Department of Energy
DNN: Defense Nuclear Nonproliferation
NA-22: Defense Nuclear Nonproliferation's Office of Research and Development (DNN R&D)

Purpose: The purpose of this guide is to help ensure that mission-relevant language used in all consortium-affiliated presentations and publications aligns properly with DNN TECH research being conducted, and to avoid unnecessary conceptual confusion and distractions. If you plan to diverge significantly from the nature of the language suggested below, please pass it through consortium leadership (e.g., Executive Team, TECH Area Leads, National Laboratory POCs) that have the relevant knowledge.

Please note that all national laboratory colleagues must have their presentations and publications reviewed by internal laboratory procedures before public release. While this is not required for our fundamental university research, if a national laboratory collaboration becomes a co-author on your presentation or publication, it will be required by them before public release (and therefore also for you). Alternatively, if your research is designed to be complementary or more fully in line with a national laboratory project (where a collaborator will likely be a co-author), it should go through the national laboratory review process before release. It is assumed that these DOE/NNSA national lab projects are more on the applied than fundamental side of R&D. Please let Jason know if you have any questions.

Defense Nuclear Nonproliferation's Enabling Capabilities in Technology TECH Mission Overview: Preventing nuclear weapons proliferation and reducing the threat of nuclear and radiological terrorism around the world are key U.S national security strategic objectives that require constant vigilance. The Department of Energy (DOE) National Nuclear Security Administration's (NNSA) Office of Defense Nuclear Nonproliferation (DNN) works globally to prevent state and non-state actors from developing nuclear weapons or acquiring weapons-usable nuclear or radiological materials, equipment, technology, and expertise. DNN TECH's sponsoring office is referred to as NA-22, which is NNSA's DNN Research and Development (R&D) objectives.

DNN's Enabling Capabilities in Technology (TECH) consortium has been formed to create new scientific knowledge in areas critical to DNN's nuclear nonproliferation mission, to apply new knowledge toward the creation of new nuclear nonproliferation capabilities, and to generate the human capital needed for the DOE/NNSA laboratories to address emerging challenges in nuclear nonproliferation.

TECH's primary goals are to educate a talented group of professionals for roles in DOE National Laboratories and related sectors, and to promote innovation through collaboration with national lab partners. This initiative includes a comprehensive approach involving joint mentorship by faculty and lab experts, a broad research portfolio covering both fundamental and applied sciences, and an extensive educational and training program.

PROJECT OBJECTIVES

Our project objectives are organized across three main T**EC**H areas and three cross-cutting T**EC**H areas. Our research approach together addresses seven of the FOA topics, which will be referred to by number in the FOA:

1. Develop new technologies and methods to detect, locate and characterize production of special nuclear material and others, such as tritium. The fate and transport in the environment of relevant effluents is an important consideration.
2. Develop new technologies and methods for nuclear incident response.
3. Develop new methods and technologies to safeguard nuclear material and detect diversion of it from civilian nuclear power purposes.
4. Develop new remote sensing tools and applications in support of nuclear nonproliferation. DNN R&D defines remote sensing as sensing at distances greater than 100 meters, both terrestrial and space based.
5. Develop new or improved laboratory measurement capabilities of environmental samples, both gas and particulate, in support of nuclear nonproliferation.
6. Develop data science, machine learning, and artificial intelligence methods and applications in support of these objectives. This also includes the development of digital twins relevant to nuclear nonproliferation as well as the incorporation of computer vision and augmented/virtual reality capabilities to enhance mission planning and effectiveness.
7. Develop solutions to future nuclear nonproliferation priorities by identifying and leveraging or countering emerging and disruptive technologies.

The DNN relevance key words below correspond to research portfolios within the DNN (NA-22) office.

Earth, Environmental, Atmospheric and Space Science (EEAS / TECH Area 1)

DNN relevance: Remote sensing, nuclear detonation detection, HEU/WGPu production detection (only cite the areas relevant to your presented research)

Nuclear activities – including material development and explosion – create various signatures in the Earth systems detectable by various technologies including satellite remote sensing from space. These signatures include the changes in environmental chemistry and isotopic compositions, atmospheric aerosols and biological systems as well as seismo-acoustic and radiation signals from detonation. DNN requires the abilities to rapidly capture these signatures using local and remote sensing, and to distinguish them from the background, as well as to trace their transport for source identification. Our work develops a comprehensive framework – based on the state-of-the-art Earth science and technologies – for detecting and locating nuclear material production as well as nuclear detonation in foreign countries through capturing and interpreting these signatures. We will advance analytical methods and technologies to quantify these signatures using environmental sampling, sensors and sensor networks. These analytical capabilities will be coupled with latest machine learning methods and fate and transport simulations for source detection, localization, and characterization.

Radiochemistry, nuclear chemistry, and nuclear chemical engineering (RNC/NCE / TECH Area 2)

[TECH area leads and lab POCs: your suggested edits are welcome here]

DNN relevance: Remote sensing, HEU/WGPu production detection, nuclear detonation detection, laboratory analysis enhancement, data science, HEU production detection? (only cite the areas relevant to your presented research)

The research area of radiochemistry, nuclear chemistry, and nuclear chemical engineering develops a fundamental understanding of physical and chemical properties of actinides and fission products in environmental and nuclear systems. These understandings include those associated with alternative and emerging fuel cycles, and it is critical to develop new and improved capabilities that can potentially be used to identify trace actinides near undeclared nuclear facilities, monitor processes at declared nuclear facilities, and detect nuclear weapon tests. Improving capabilities to rapidly detect and confidently respond to a nuclear event is important because it is one of the most effective mechanisms for deterring the future use of nuclear weapons.

Advanced nuclear fuel and reactor systems engineering (ANF/RSE / TECH Area 3)

DNN relevance: Safeguards, data science, HEU/WGPu production detection (only cite the areas relevant to your presented research)

The advanced nuclear fuel and reactor systems engineering topic focuses on the future of the fission and fusion reactor systems that will be deployed to provide an enormous increase of power in the coming decades. In particular, several Gen-IV advanced reactor concepts that are expected to be widely deployed in coming years adopt fuel designs and operation modes that challenge or outright break the long-standing item-based model of spent nuclear fuel safeguards. Additionally, some of the fundamental characteristics of these emerging fuels are not yet understood. Meanwhile, these reactor concepts also offer new opportunities to implement safeguards-by-design, which includes predicting and measuring compositions during reactor operation, as well as detecting and diagnosing material diversion scenarios. Our work characterizes emerging fuels and develops advanced diagnostic techniques based on artificial intelligence (AI), machine learning (ML), innovative measurement techniques, and digital twins coupled with advanced modeling and simulation (ModSim) capability to measure, monitor, and predict the elemental and isotopic composition of irradiated fuel and detect and localize material diversion scenarios on- and off-line. The advances in measurement and ModSim technology and advanced data analytics to be achieved in this research area will introduce a paradigm shift in the material control and accounting (MC&A) approach for advanced reactors. Research in this area also seeks to understand the production and material attractiveness of SNM and tritium in inertial confinement and magnetic confinement fusion reactors.

Detection, characterization, and response methodologies and tools (DCR / TECH Area 4)

DNN relevance: Radiation detection, safeguards, nuclear detonation detection, remote sensing, search, incident response (only cite the areas relevant to your presented research)

The new DCR methodologies and tools provide enabling capabilities for detection and monitoring of foreign production of special nuclear materials and weaponization activities; for remote nuclear detonation detection, localization, and characterization; for near field detection, localization, characterization of nuclear and energetic materials and items that may be a threat or that have gone out of regulatory control; and for assay, monitoring, and accountancy of nuclear materials associated with alternative and emerging fuel cycles and advanced reactors. Sensing from the near field, to the fenceline, and even to outer space can be improved by observing the right signals at the right place and time; understanding the fate, transport and propagation of the *signals; and improving the sensitivity of detection through advanced signal processing and algorithms, improved understanding of background, and advances in modeling and simulation.*

Data science for nuclear nonproliferation (DSNN / TECH Area 5)

DNN relevance: Data science, radiation detection, safeguards, search, incident response (only cite the areas relevant to your presented research)

The unprecedented amount of data available to the nonproliferation community through persistent observation, large measurement campaigns, simulation tools and digital twins, offers the opportunity to leverage data science techniques including artificial intelligence and machine learning to extract complex and often hidden insights from data, as well as to develop new algorithms that advance the state-of-the-art. Data science technologies are also key to addressing emerging challenges in nuclear nonproliferation posed by the rapidly evolving and complex threat landscape of the modern era. These technologies are further enabled by advances in exascale computing, supercomputing architectures, and edge computing.