Testimony of

Dr. Thomas Peterson, Assistant Director
Engineering Directorate
National Science Foundation

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Keeping America Secure: The Science Supporting the Development of Threat Detection Technologies.

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Chairman Hall, Ranking Member Johnson and other distinguished members of the Committee on Science, Space, and Technology, it is a pleasure to be able to testify before you today on the important topic of "Keeping America Secure: The Science Supporting the Development of Threat Detection Technologies". I am Tom Peterson, Assistant Director for Engineering at the National Science Foundation. I would like to briefly describe our efforts in this research area, both in terms of investments made exclusively by NSF and in terms of important interagency partnerships we have, particularly with the Department of Homeland Security (DHS).

The primary mission of the Foundation is to support basic research in science and engineering, as well as advancements in education in science, technology, engineering and math (STEM) disciplinary areas. This mission to support *basic* research, independent of specific topical area, allows NSF to support creative and innovative ideas generated by the community in an incredibly broad spectrum of topics. At the same time, the Foundation has an obligation, as stated clearly in the NSF Act of 1950, "To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." So it is appropriate that some portion of our basic research investments touch on issues related to national security.

While the Foundation is comprised of seven directorates and four offices focusing on specific disciplinary research and education activities, the strength of the NSF is in our ability to reach deeply into the academic community across a broad range of areas. This "OneNSF" philosophy gives us the capability to advance science and engineering in ways that could not be done with a more focused, disciplinary or mission-oriented approach. To truly understand threat detection technologies requires expertise not only in engineering and physical sciences, but in life sciences, social and behavioral sciences and education as well. NSF serves all those communities, and our support in this area taps on all those strengths.

Support through Core Programs

First, important fundamental issues of advancing our understanding of threat detection are funded through the core programs in many divisions throughout the Foundation, particularly in Engineering (ENG), in Computer and Information Science and Engineering (CISE), and in Social, Behavioral, and Economic Sciences (SBE). For example, the "Resilient and Sustainable Infrastructures" cluster within ENG focuses on issues of importance in responding to both natural and man-made disasters. Understanding, for example, how social media and the ubiquitous presence of cell phones can help to mitigate the delayed response to disasters creating social disruption can help us improve our emergency management capabilities.

Another example of work funded in this area studies the technology for automatic detection and real-time mitigation of deliberate hazardous releases in infrastructure systems. This work can be used to help protect, in a reliable, cost-effective and socially acceptable way, passenger terminals, transportation tunnels, tall buildings or even a channel carrying water to a municipality. This work is being done at the University of Michigan.

Work on development of sensors and sensor networks is supported in a number of divisions and directorates, where the fundamentals of sensor devices and technologies are examined, as are the uses of bio-electronics, optical imaging and sensing, optical devices and components, and even optical devices based on meta-materials.

Work supported at the University of Utah focuses on unique configurations for gas chromatography to enable portable and high-capacity analyses of various airborne pollutants and contaminants, such as volatile organic compounds, thereby providing early warning for individuals.

And within our collaborative Industry University Cooperative Research Center (IUCRC) program, a biometrics center focusing on identification technology is supported at Clarkson University, West Virginia University, the University of Arizona and SUNY Buffalo. The center focuses on automated human biometric recognition in order to identify the actors likely associated with planning and executing asymmetric threats. The Center works closely with the Department of Homeland Security, the Department of Defense (DoD), the FBI and many other agencies.

While much work has been supported, and continues to be supported, through the core programs within the NSF, there have been specialized solicitations focusing exclusively on issues related to threat detection. Some of those solicitations are in partnership with DoD and DHS.

In collaboration with the DoD, work supported primarily by SBE at NSF has examined the social and behavioral foundations of terrorism, and includes for example, an award to the University of Maryland for the systematic analysis of unclassified empirical data on terrorist organizations, along with data on similar political organizations that choose not to use terrorism. Also supported was an award to the University of Texas-Dallas on the substantive expertise, strategic analysis and behavioral foundations of terrorism.

Partnerships with DHS

Perhaps our most significant contributions to this effort have come about through a long-standing and productive partnership with DHS. It is a program jointly executed by the Domestic Nuclear Detection Office (DNDO) and NSF, and it was established via a Memorandum of Understanding in 2007. Since the inception of this productive partnership, two distinct solicitations have been run.

The "Academic Research Initiative" seeks to advance fundamental knowledge for nuclear detection and related sciences, to develop human capital and address the graying of the nuclear science profession by training the next generation of nuclear engineers and physicists, and by sustaining a long-term commitment to frontier academic research in the field. This is about a $50 million effort that has been a groundbreaking collaboration between NSF and DHS on detection of domestic nuclear threats (aka, domestic nuclear terrorism). This solicitation has been run five times.

The second solicitation involving a DHS partnership (in this case, the Explosives Division of the Science and Technology Directorate) is "Explosives and Related Threats: Frontiers in Prediction and Detection".

Academic Research Initiative

The Academic Research Initiative partnership between NSF and DNDO of DHS has run a solicitation five times since its inception in 2007. The preponderance of investments have focused on the development of better and more sophisticated detectors for nuclear and actinide materials. Major technical challenges addressed by the efforts below include: radiation monitoring along the Nation's unattended land and sea borders; agile, mobile and re-locatable radiation detection and monitoring; unattended or ubiquitous radiation detection sensing systems; and high capacity, low dose scanning/screening technologies for cargo. For example:

- Researchers at Washington State University have investigated the effect of adding metallic nanoparticles to high-density scintillator materials to enhance the sensitivity and applicability of scintillator materials for nuclear threat detection.
- A research team from the City College of New York, Optical Semiconductors, Inc. and the Department of Energy's (DOE) Brookhaven National Laboratory combined efforts in spectroscopic characterization, material growth, and device manufacturing/testing to improve cadmium-magnesium-tellurium (CdMgTe) as the material of choice for room temperature gamma-ray detectors.
- A research team at UNC Chapel Hill and NC A&T is examining various techniques being developed to detect nuclear materials in large cargo containers based on gamma-ray beams to identify specific isotopes. High intensity gamma-ray beams with good energy resolution are expected to generate acceptable radiation doses to cargo and to enable scans to be performed in short enough times that make these techniques viable solutions. An ultimate goal is to apply this technology as the basis for systems that make isotope-specific images of high-Z materials in cargo containers.
- Purdue University researchers are trying to develop graphene-based sensors for detecting special nuclear materials because graphene is an electronic material with unique properties. Graphene-based radiation sensors have the potential to significantly outperform existing sensors for detecting special nuclear materials. Other researchers at Purdue are studying tensioned fluid metastable states as a basis for novel, transformational impact, low-cost, effective, portable particle detector systems to detect highly-enriched uranium and other

special nuclear materials. These "tensioned" metastable states in materials potentially offer unique, unsurpassed capabilities for detection.

- University of Hawaii researchers are evaluating the use of differential absorption and differential fluorescence for the detection of fissionable nuclear materials concealed by terrorists in shipping containers, road vehicles, aircraft and ships. Differential absorption and fluorescence have long been used effectively at optical and x-ray wavelengths to identify materials and structures that would otherwise be undetectable due to the higher levels of absorption or fluorescence by the materials in which the structures of interest are embedded.

Not all research focuses exclusively on detector technology.

- Researchers at Virginia Commonwealth University explored how a systems approach can be used to design and analyze systems for detecting nuclear material at our nation’s ports. This research uses discrete optimization and decision analysis models to design multi-layered, risk-based, port security systems for detecting nuclear weapons and materials. Rutgers University addresses the issues of interpretation of data, responsive action, and managing the information generated by complex sensing systems. They address decision and control based on sensor information, and on incorporating uncertainty and risk into decision-making for use with imperfectly sensed data.
- Collaborators at Texas A&M University conduct research to demonstrate the ability to develop and deploy new detector concepts with fully integrated signal and information analysis to attain breakthrough improvements in the nation's ability to detect domestic nuclear threats. Their work involves (1) integration of social science/policy factors into the detection system parameter space, (2) enhancement of the education of undergraduate and graduate science and engineering students in areas related to nuclear security and border monitoring research, and (3) generation of self-sustaining research teams which will continue to expand fundamental knowledge in key nuclear detection fields.
- Efforts at UT-Austin are underway to develop a class of stochastic interdiction models on a transportation network consisting of two adversaries: a smuggler and an interdictor. The models are hierarchical, stochastic, and involve strategic gaming, and allow for testing of detection techniques employed by the interdictor and responses by the smuggler. The interdictor's goal is to minimize the probability the smuggler avoids detection. The intellectual merit of the work addresses stochastic interdiction optimization, probability and statistical modeling of uncertainties, and nuclear radiation transport modeling and analysis.
- Iowa State researchers are developing an informatics-based approach to the accelerated design and discovery of new radiation detector materials. The research integrates the formal methods of statistical learning in information theory to first-principles and mesoscale modeling, measurements of radiation detection characteristics, and novel high-throughput screening and modeling studies of defects in inorganic scintillator materials. This interdisciplinary collaborative is facilitated by a cyberinfrastructure for data sharing between Iowa State University (ISU), Case Western Reserve University (CWRU) and DOE’s Los Alamos National Laboratory (LANL).
- Researchers at The University of Tennessee are addressing fundamental aspects of manufacturing technology that directly impact the affordability of the high-performance detection materials that are needed for effective high-speed scanning of cargo. Innovative synthesis techniques are being developed with the goal of improving the sensitivity and lowering the cost of materials that have the capability of uniquely identifying specific nuclear threats.

- A unique approach to nuclear forensics discovery is being taken at UC-Berkeley, where they are recasting nuclear forensics discovery as a digital library search problem. Nuclear forensics is the science of identification of source and characteristics of smuggled nuclear materials possibly seized by authorities. Nuclear material identification is of utmost importance to international threat reduction. The nuclear materials identification process will be cast as a search problem against a digital library of standard nuclear materials samples and their digital signatures.

Explosives and Related Threats: Frontiers in Prediction and Detection

A solicitation entitled "Explosives and Related Threats: Frontiers in Prediction and Detection" was issued by all seven directorates and two of the four offices within the Foundation. This solicitation followed NSF's investment in leading-edge frontier research on sensors and other areas, including the social and behavioral sciences that are potentially relevant to the prediction and detection of explosives and related threats. It sought to advance fundamental knowledge in new technologies for sensors and sensor networks, and in the use of sensor data and control systems in decision-making, particularly in relation to the prediction and detection of explosives and related threats. Examples of awards from that solicitation include:

- At Caltech, research to develop sensor arrays for vapor detection using chemically sensitive resistors and luminescent polymers together with biologically inspired algorithms to analyze and interpret the data. The work can potentially lead to a general purpose, trainable sensor.
- At the University of Connecticut, an ultra-thin molecular sieving zeolite membrane serves as an explosives vapor concentrator and single-walled carbon nanotube (SWNT)-porphyrin conjugates serve as sensing elements. These and other features promise to impart onto the electronic nose an unprecedented speed, sensitivity and selectivity, as well as a technology that can be readily miniaturized and applicable for remote surveillance devices.
- Researchers at GaTech are developing integrated planar optical waveguide spectrometry-interferometry for sensing explosives with imprinted polymers. Synthesis of molecularly imprintable polymers with reactive groups increase signal to noise and selectivity of the compounds to be detected.
- Collaborators at Princeton and George Mason University are working on improving nuclear quadrupole resonance (NQR) detection of explosives. NQR is desirable as it is a penetrating method of detection, and a practical implementation is addressed with the conceptual design of a device which mounts under a floor.

Conclusion

NSF continues to support fundamental research and education in science and engineering, primarily for ideas generated by the academic community. Our ability to bring together a broad range of disciplines within that academic community is particularly beneficial in addressing complex issues such as the ones we are discussing today. By marshalling our expertise in collaboration with the strong mission-oriented foci of other agencies such as the Department of Homeland Security, we have been able to contribute significantly, I believe, to advancing fundamental research relating to the detection of physical threats to our nation and its people. In challenging budget times, partnerships such as this one can be threatened. It is my hope that we can continue to work collaboratively with our colleagues in DHS/DNDO, DoD, and other agencies, and to make valuable contributions to knowledge in this obviously important area. I thank the Chairman and the committee once again for this opportunity to highlight NSF's contributions. I would be happy to answer any questions.