Testimony of
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Chairman Hoeven, Ranking Member Shaheen, and distinguished Members of the Subcommittee, I am honored to appear before you today to testify with my esteemed colleagues from the U.S. Department of Homeland Security (DHS) in support of the President's Fiscal Year (FY) 2017 Budget. The President's budget request includes $151.6 million for research and development (R&D) to defend the Homeland against the threat of radiological and nuclear terrorism. The Domestic Nuclear Detection Office (DNDO) is charged with and is committed to advancing our Nation's technological edge to defeat sophisticated and agile adversaries against this threat, principally through nuclear detection and technical nuclear forensics.

My testimony today will center on the President's FY 2017 budget request for R&D under DNDO's purview, as well as the process by which we carry out these functions. It will also highlight recent accomplishments attributable to our current R&D model.

Three themes underpin my testimony. First, our R&D successes are the result of our end-to-end approach that enables a thorough understanding of the threat, operational issues, and available technologies. Second, healthy collaboration with the user community and research partners enables the exchange of information essential to make progress. Third, while we have our share of technical expertise, the critical mass of technical capability resides in our national laboratories, academia, and industry, and we have focused a great deal of our efforts to sustain the technical expertise for future advances.

Mission and Authorities

As stated in the President's National Security Strategy, "No threat poses as grave a danger to our security and well-being as the potential use of nuclear weapons and materials by irresponsible states or terrorists." The potentially catastrophic effects of a nuclear detonation, whether executed by a state or a non-state actor, would have far-reaching impacts on our Nation and the world.

Recognizing the grave threat of nuclear terrorism, DNDO was established in 2005 via National Security Presidential Directive (NSPD)-43/Homeland Security Presidential Directive (HSPD)-14 and subsequently authorized via the Security and Accountability For Every (SAFE) Port Act of 2006 (P.L. 109-347) to "serve as the primary entity of the United States Government to further develop, acquire, and support the deployment of an enhanced domestic system to detect and report on attempts to import, possess, store, transport, develop, or use an unauthorized nuclear explosive device, fissile material, or radiological material in the United States, and improve that system over time." The National Technical Nuclear Forensics Center was established within DNDO in 2006 by NSPD-17/HSPD-4 and was authorized by the 2010 Nuclear Forensics and Attribution Act (P.L. 111-140) to "ensure an enduring national technical nuclear forensics capability to strengthen the collective response of the United States to nuclear terrorism or other nuclear attacks."

DNDO is responsible for conducting an aggressive, expedited, evolutionary, and transformational program of R&D to generate and improve technologies to detect and prevent the illicit entry, transport, assembly, or potential use within the United States of a nuclear explosive device or fissile or radioactive material. DNDO is also responsible for advancing technologies to accurately and rapidly attribute the source of interdicted nuclear materials.

DNDO's R&D efforts cover four mission areas: Transformational R&D, Nuclear Forensics, Detection Capability Development, and Detection Capability Assessment.

Transformational R&D

Within Transformational R&D, DNDO manages four programs spanning basic research, applied research, and technology development:

- Advancing the fundamental knowledge in nuclear detection and forensics, the **Academic Research Initiative** (ARI) focuses on basic and early applied R&D to address key challenges and at the same time educate the next generation of scientists and engineers. The President's FY 2017 request for the initiative is $11.8M and will include such work as transferring large solid state and no-power neutron detectors necessary for detecting nuclear material such as plutonium to industry partners for covert and extended life operations. Additionally, the budget request for the program will continue to support over 100 students at over 30 universities.

- Assessing the feasibility of promising R&D concepts, the **Exploratory Research Program** (ER) focuses on later applied R&D through laboratory proof-of-concept demonstrations. The budget request for the program in FY 2017 is $26.1M and will include work such as the demonstration of compact and inexpensive betatron x-ray sources to enable highly mobile non-intrusive inspection systems to detect shielded threats.

- Building on R&D concepts previously demonstrated under the ER or other R&D efforts, the **Advanced Technology Demonstration Program** (ATD) further develops these technologies and characterizes them in a simulated or controlled operational environment to assess performance and operational utility. The President's FY 2017 request is $24.1M for the Advanced Technology Demonstration program and will include work such as the operational assessment of a machine learning algorithm to further reduce nuisance alarms in radiation portal monitors.

- The purpose of the **Small Business Innovation Research Program** (SBIR) is to stimulate technological innovation by strengthening the role of innovative small business concerns in federally funded R&D. The program has been successful in transitioning near-term solutions into commercial products or services, such as the development of a fast neutron detector material called stilbene. In FY 2017, the program will support 13 projects, which will include transitioning thallium bromide detectors for radiation pagers to a proof-of-concept.

The portfolios include materials development and supporting technology, radiation detection techniques, shielded threat detection, advanced analytics, and nuclear forensics. The President's FY 2017 budget request for Transformational R&D is $64.8M.

Nuclear Forensics

DNDO's Nuclear Forensics portfolio is organized into three mission areas: operational readiness, technology advancement, and nuclear forensics expertise development. The FY 2017 request for Nuclear Forensics is $20.6M and includes programs such as:

- The **Technology Advancement Program** benchmarks and advances forensics methodologies to provide well-understood results and develops signatures and data evaluation tools to support attribution assessments. These methods and signatures are provided to operators in the Federal Bureau of Investigation, Department of Defense, Department of Energy, and intelligence community. The President's FY 2017 request is $9.6M for the Technology Advancement Program and will include such work as the operation of laboratory-scale processing capabilities that produce uranium and plutonium materials for forensics signatures.

- The **National Nuclear Forensics Expertise Development Program** addresses the enduring challenge of sustaining a preeminent workforce of scientists and engineers in nuclear forensics-related specialties. The program consists of Graduate Fellowships, Post-Doc Fellowships, Summer Internships, a Nuclear Forensics Research Award, and an Early-Career Award. The President's FY 2017 request of $5.0M will support a total of 39 awards.

Detection Capability Development

DNDO's Detection Capability Development portfolio addresses the development of technical solutions for detecting nuclear and other radioactive material in various operational environments and along challenging pathways. The following programs are among the activities of Detection Capability Development, for which the President has requested $21.5M:

- The **International Rail Program** (IRAIL) analyzes options, develops a programmatic approach for implementing solutions, and generates requirements and solutions for detecting and identifying illicit nuclear or other radioactive materials entering the United States via freight rail cargo through the 31 ports of entry identified in the Trade Act of 2002 (P.L. 107–210). The President's FY 2017 request is $3.1M and will support activities for detection solutions for freight rail cargo.

- The **Aerial Detection Program** seeks to provide a capability via an aircraft-borne detection system during intelligence-driven operations to detect and intercept nuclear and other radioactive threats at distances far removed from major population centers and critical infrastructure, and with faster response times than interdictions made via boats and cutters. The President's FY 2017 request of $3.1M will include system development activities to determine operational effectiveness and suitability of currently-available commercial products.

Detection Capability Assessments

DNDO's Detection Capability Assessments portfolio supports the R&D and acquisition process for mission-related capabilities. The President's request for FY 2017 for Detection Capability Assessments is $44.7M, and the following programs are a subset of those activities:

- The **Test and Evaluation Program** conducts rigorous assessment of radiological and nuclear detection capabilities to inform acquisition decisions and to develop and implement effective concepts of operation. The President's FY 2017 request of $17.8M will include the planning, execution, and reporting of 11 test campaigns.

- The **Studies and Infrastructure Program** objectively assesses the effectiveness and performance of global nuclear detection architecture programs and processes. The program also supports the development and maintenance of radiological and nuclear detection standards and associated conformity testing. The President's FY 2017 request is $9.4M and will include work such as the publication of advanced radiography and aerial radiation detection technical capability standards.

- The **Operational Readiness Assessments Program** evaluates deployed systems and operations as well as the performance of detection technologies in operationally-relevant and controlled environments. The President's FY 2017 request of $8.6M will include work such as piloting a computer application that analyzes radiation portal monitor scans for reducing nuisance alarms, simplifying alarm adjudication, and increasing threat sensitivity.

Strategic Approach

To successfully detect, interdict, and conduct nuclear forensics on nuclear and other radioactive material, it is essential that we rely on the critical triad of intelligence, law enforcement, and technology. To maximize the Nation's ability to detect and interdict a threat, it is imperative that we apply detection technologies in operations that are driven by intelligence indicators, and place them in the hands of well-trained law enforcement and public safety officials. Similarly, to enhance attribution capabilities, the U.S. Government (USG) must ensure that information from intelligence, law enforcement, and technical nuclear forensics is synthesized to identify the origin of the material or device and the perpetrators.

Addressing the threat of nuclear terrorism requires a whole-of-government approach, with partners at all levels of government. At the federal level, U.S. Customs & Border Protection (CBP), U.S. Coast Guard (USCG), and the Transportation Security Administration play a critical role in countering nuclear threats at our borders, in aviation and maritime environments, and in our domestic transportation system. Similarly, at the state and local level, law enforcement and public safety partners are essential to the detection and interdiction of nuclear threats in their areas of operation and jurisdiction. DNDO aims to dramatically evolve nuclear detection and technical nuclear forensics capabilities and to further reduce the cost of advanced technology without causing operational burden to operators.

The initial R&D investment in nuclear and radiological detection devices is extremely more costly than most other products. It is therefore imperative that DNDO fund early research to lower the technical risk and raise the readiness of the material or technology to a point where industry is willing to absorb the remaining risk and develop a product. Thus, DNDO invests in

innovative, high-risk, early-stage technologies, subsequently transitioning them to industry for commercialization. This positions DNDO to acquire fully integrated systems once they are commercially available. This approach not only enables industry to rapidly improve detection technologies and enhance existing products, but it also stimulates industry to innovate in this mission space. DNDO has successfully transferred many technologies to industry for direct commercialization.

Recognizing that some solutions may not require government development, DNDO now uses a "commercial first" acquisition strategy, engaging first with the private sector for existing solutions and only moving to a government-sponsored and managed development effort if necessary. This approach leverages industry-led innovation, takes advantage of industry's innate flexibility and ability to rapidly improve technologies, and reduces government-funded development efforts. In some cases, shifting to commercial-based acquisitions will reduce the total time to test, acquire, and field technology.

Process

DNDO applies a holistic, end-to-end approach to countering nuclear terrorism, beginning with a comprehensive understanding of the threat, including the material, the device, and the adversary. We integrate planning, research and technology development, testing and evaluation, and technology acquisition, with operational support to federal, state, and local operators. For detection, our end-to-end approach begins with the development of an enhanced global nuclear detection architecture, which is a framework for detecting, analyzing, and reporting on nuclear and other radioactive materials that are out of regulatory control. Likewise, through the National Technical Nuclear Forensics Center, DNDO integrates planning, R&D, and operational readiness to improve the USG's nuclear forensics capabilities.

DNDO's approach enables seamless integration of R&D programs into the full systems engineering lifecycle from identification of a technology need to deployment of a system to the field. Our Solution Development Process provides the mechanism to manage programs in compliance with DHS acquisition life cycle stage gates, effectively integrating these programs within the appropriate governance frameworks, and successfully applying the best practices of industry and government. We are participating in the reconstituted DHS Joint Requirements Council as it works to assess joint requirements for several investment portfolios.

The Solutions Development Process is focused on the execution of an individual solution development from gap identification to post deployment activities. The first stage involves an analysis whereby gaps in the global nuclear detection architecture and technical nuclear forensics are identified and prioritized. Recognizing the continually evolving threat and the framework of defense, DNDO annually reviews multiple sources, including the global nuclear detection architecture analysis process (which includes threat modeling and risk assessment), guidance from the national technical nuclear forensics community, direct end-user interaction, recommendations from external portfolio reviews, and interactions with other USG R&D organizations.

Next, the identified gaps and needs from the first stage are translated to prioritized programmatic needs to inform DNDO's budget formulation and decision process. The results of the gap analyses provide both concepts for specific topic areas, as well as perspective on other research areas that could broadly address a range of capability gaps. These gaps translate into the long-

standing technical grand challenges, which ultimately form the research areas that make up DNDO's R&D portfolio.

In subsequent stages, a given solution progresses from planning and analysis to a selection of options. Typically, program documentation required as part of these stages include a Mission Needs Statement, Analysis of Alternatives, and Operational Requirements Documents, all of which require close end-user collaboration. As it relates to R&D, DNDO continually engages stakeholders to better understand DHS end-user operations and nuclear detection requirements to inform R&D. Following the planning and selection stages, DNDO, jointly with operators, defines solution requirements and implements design, development, and testing. This is followed by the procurement and deployment of a system based on life cycle costs. DNDO also performs a post-implementation review to examine the systems deployed to the field. At each stage of the Solutions Development Process, the Governance Review Board, comprised of DNDO leadership and operational partners, conducts corresponding reviews to assess the health of the program.

One example of a capability that matriculated through the Solutions Development Process is the development of a next-generation radioisotope identification device. We worked closely with our partners to identify key operational requirements that drove the new system design. Based on an enhanced detection material, lanthanum bromide, and improved algorithms, this new handheld technology is easy-to-use, lightweight, and more reliable. Because it has built-in calibration and diagnostics, it has a much lower annual maintenance cost.

Another example that demonstrates DNDO's end-to-end approach is the joint effort between CBP and DNDO to address the high volume of nuisance alarms generated by deployed radiation portal monitors at our ports of entry. Under DNDO's Radiation Portal Monitor Program, DNDO and CBP implemented a new approach using Revised Operational Settings (ROS) to deployed portal monitors. This collaboration and effort resulted in an average reduction of approximately 75 percent of nuisance alarms without sacrificing detector performance against threat materials, allowing officers in the field to redirect their time to other high priority law enforcement duties. The FY 2017 budget request for R&D includes work to continue to improve processes to further reduce nuisance alarms.

Collaborations and Partnerships

Research and development of new or improved capabilities to aid in nuclear defense and countering the threat of nuclear terrorism principally rests with three organizations: DHS's DNDO, the Department of Energy (DOE) National Nuclear Security Administration's Office of Defense Nuclear Nonproliferation Research and Development, and the Department of Defense's (DoD) Defense Threat Reduction Agency. All have substantial, well-focused R&D programs that address technical gaps in threat detection and interdiction capability, focused on the unique needs of their respective mission areas and stakeholders. Further, the Office of the Director of National Intelligence plays an important intelligence and operational role in supporting the interagency research agenda.

The interagency works jointly to assure the highest caliber research is solicited and selected by the Federal Government. These activities include advance sharing of potential research topics, and supporting each other's solicitation processes through technical advice and joint proposal reviews. Specific recent examples include collaborations with the Defense Advanced Research

Project Agency (DARPA) SIGMA program on distributed radiation detection networks and DNDO's collaboration with the New York City Police Department on the Radiation Awareness and Interdiction Network (RAIN) Advanced Technology Demonstration.

Within DHS, DNDO collaborates and coordinates with the USCG R&D Center and the Science and Technology Directorate (S&T), which performs R&D to support other DHS mission areas such as explosive detection. Some of the technologies developed by S&T can be utilized to detect radiological or nuclear threats. For example, if S&T develops a Non-Intrusive Inspection (NII) x-ray scanner to more effectively detect drugs, explosives, or other contraband, these devices may also be effective in detecting radiological and nuclear threats. Further, DNDO also fully and actively supports relevant Integrated Product Teams led by S&T, including one on border security.

DNDO also works closely with international partners on R&D through bilateral project arrangements. Two examples include:

- **United Kingdom**: DNDO and the U.K. Home Office are jointly developing and evaluating three transformational imaging and radiation detection technologies for cargo scanning at ports of entry and departure, one of which is also in collaboration with S&T.
- **Singapore**: DNDO and the Singapore Ministry of Home Affairs conducted an operational trial in Singapore of the DNDO developed RadMap System, which can detect and localize radioactive materials while moving, as well as overlay radiation data with visual and laser imaging data to enable a 3D reconstruction of the environment.

DNDO continues to work with international stakeholders with similar radiological and nuclear detection goals and national capabilities in the area of R&D. Leveraging agreements between DHS and foreign organizations will allow DNDO to identify areas of mutual concern and compare research portfolios to minimize overlap in parallel efforts and maximize the breadth of R&D being done across mutual portfolios.

Measuring Progress

To gauge the success of DNDO's R&D programs we internally track metrics that are indicative of progress and sponsor external reviews to assess the health and balance of our R&D portfolio. DNDO internally tracks the following metrics: program milestones, technology readiness level advancements, publications in peer-reviewed journals, presentations at recognized scientific conferences, intellectual property, licenses for software, awards in recognition of scientific achievements, and the number of students supported. Some of these metrics provide information about the progress and technological maturity of the projects and can also be used to assess the viability of technology transitions. Others indicate the ability to disseminate information to the broader scientific community and give insight into DNDO's efforts to cultivate the next generation of scientists and engineers for the nuclear-related missions. For example, DNDO's Chief Scientist patented a method and device for detecting moving radiation sources. The technique detects radioactive sources that are in motion and facilitates the rapid and accurate identification of the source of radioactive material. This invention is intended for use at seaports and border crossings that screen cargo containers, vehicles, or pedestrians for nuclear or other radioactive materials and in mobile radiation detectors deployed in search operations.

Additionally, we sponsor external reviews of our R&D portfolio and will continue to do so in the future. For example, in 2013 and 2015, DNDO sponsored reviews by an independent party to assess DNDO's existing R&D plan and portfolio, evaluating the composition, positioning, and health of the portfolio as a whole against the strategic objectives of DNDO. The review committee consisted of subject matter experts, customers, interagency R&D partners, and DNDO management.

Accomplishments

Over the last several years DNDO investments in R&D have resulted in technologies that have transitioned from laboratories to commercial products used for homeland security. Some of those examples are listed below:

- **Neutron Detectors for Portal Monitors:** DNDO research directly facilitated the development of new materials to address the critical shortage of helium-3, the primary material used by radiation detectors to detect neutrons.[1] Several different concepts were developed and evaluated, e.g., boron-coated straw proportional counters, and are now commercially available. The alternative materials outperform helium-3 and are less expensive and more sustainable.

- **Combined Gamma and Neutron Detector Material**: DNDO research directly facilitated the development of cesium lithium yttrium chloride (CLYC), a single scintillator material capable of both gamma and neutron detection.[2] Previously two different detector materials had to be used, and sensors using CLYC are now commercially available in detectors that are more compact, lower power, lower cost, and more rugged than in the past. Due to its ability to detect neutrons as well as gamma rays, CLYC now stands as a viable helium-3 replacement for handheld detectors.

- **Small Business-Developed Detector Material:** Through the Small Business Innovation Research Program, DNDO supported the development of an improved process for the manufacture of stilbene, a fast neutron detector material.[3] This is now available in the United States at lower cost and with improved performance. Previously, it had only been available from sources in the Ukraine.

- **Automated Threat Recognition Software:** The DNDO-developed Auto-Z™ algorithm analyzes X-ray radiography images of cargo to identify the objects that may be high-Z materials[4] and provides a visual "alarm" to the operator, noting the suspicious objects in the image. To date, CBP has acquired and fielded 11 systems that are equipped with Auto-Z™.

[1] Neutrons, in addition to gamma-rays, are key indicators of materials used in nuclear weapons.
[2] Some nuclear materials emit more gamma rays, and others emit more neutrons. Having one detector material that is sensitive to both of these primary emissions is advantageous.
[3] Fast neutrons emitted by nuclear material contain energy information that is helpful in identifying the source material. The advancement in fast neutron detection could lead to better identification equipment.
[4] "Z" refers to the atomic number of an element, equal to the number of protons. "High-Z" materials include lead (Z=82), and nuclear materials like uranium (Z=92) and plutonium (Z=94), in comparison to carbon (Z=6) or nitrogen (Z=7), and are typically
more dense.

- **Networked Detectors:** Prior DNDO efforts related to an Intelligent Radiation Sensor System led to new electronics, advanced algorithms, and cell phone integration, enabling commercially available networked radiation detection systems to be used for improved wide-area search capabilities. Some of this technology is also being evaluated by DNDO in collaboration with the DARPA via their SIGMA program.

- **Enabling Imaging Technology:** DNDO R&D facilitated the integration of compact dual-energy x-ray generators with improved density discrimination and higher shielding penetration into commercially available mobile radiography systems.

- **Plutonium and Uranium Processing Capability:** DNDO supported the development of a laboratory-scale plutonium processing capability to produce plutonium materials for forensics signature development. In addition, a similar, laboratory-scale uranium processing capability completed by DNDO is now operating to produce uranium materials for signature development.

Next Generation of Scientists and Engineers

DNDO also supports the next generation of scientists and engineers needed to execute the mission. DNDO invests in such expertise through the **Academic Research Initiative** by supporting areas such as advanced materials, nuclear engineering, radiochemistry, and deterrence theory. Since inception in 2007, DNDO has awarded 77 grants to 50 academic institutions, and supported over 400 students.

DNDO's **National Nuclear Forensics Expertise Development Program** is another effort to grow and sustain the scientific expertise required to execute the national technical nuclear forensics mission. The program has been recognized by the DOE national laboratories, universities, and the interagency as a major success in restoring the pipeline of nuclear forensics scientists. Launched in 2008, this effort is a key component in preventing nuclear terrorism, and DNDO has supported over 300 students and faculty, and 27 universities, since its inception.

Currently, twenty-one students are pursuing their PhDs, along with 16 post-doctoral fellows conducting research at the laboratories. Undergraduate scholarship and summer school initiatives are proving to be effective for recruiting future PhD candidates, with 15 new undergraduate participants each year.

The program's education awards have directly sponsored nuclear forensics related curriculum development and research partnerships at 15 universities around the country, including the hiring of eight new tenure-track junior faculty members. A total of 39 new Ph.D. nuclear forensic scientists are now in the workforce as a direct result of the program, already exceeding the threshold target of 35 set for 2018. These scientists are employed at the national laboratories, federal agencies, and U.S. universities.

Technical Grand Challenges

Despite the progress we have made in R&D, there are five technical grand challenges that require sustained investment and are reflected within DNDO's Transformational R&D portfolio:

- Cost-effective equipment with sufficient technical performance to ensure widespread deployment;

- Detection of special nuclear material, such as plutonium and uranium, even when heavily shielded;
- Enhanced wide-area searches in a variety of scenarios, to include urban and highly cluttered environments;
- Challenging pathways, such as between ports of entry along our land and sea borders; and
- Determination of the origins and manufacturing processes of seized material.

The fact that DNDO has supported the development of detector materials that did not exist in 2005 and which are now commercially available is a testament to the end-to-end R&D model DNDO applies to the particular set of challenges for countering nuclear terrorism.

Closing

DNDO's R&D is targeted to transform the basic building blocks of nuclear detection and technical nuclear forensics for dramatic capability improvements. We are committed to developing technologies for our partners to assist them in conducting their mission to protect the Nation more effectively. We engage in an end-to-end process, understanding the threat and user requirements; funding research, development, testing, and evaluation; engaging with industry, academia, and the national laboratories; and supporting the operator in the field. We seek the optimal solution for the problem at hand, whether it requires basic research, an off-the-shelf component, or a non-materiel capability. We are building not only equipment and capabilities, but also a trained workforce for the future.

While we have seen significant results and promising technologies, technical challenges remain and the threat landscape continues to evolve, which necessitates continual evaluation of current and future needs and R&D investments and innovations. To this end, DNDO will continue to work with the interagency, national laboratories, international partners, industry, and academia to maximize the return on federal investment.

Thank you for your continued interest in and support for these efforts.