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Abstract

To combat the threat of nuclear terrorism, the Domestic Nuclear Detection Office (DNDO) was established within the U.S. Department of Homeland Security to focus efforts on developing and enhancing radiological and nuclear detection and national technical nuclear forensics capabilities. With respect to nuclear detection, we at DNDO, in concert with interagency partners, are developing and enhancing a multi-faceted, layered, defense-in-depth framework to make prohibitively difficult the importation, possession, storage, development, transportation, or use of nuclear or other radioactive material that is out of regulatory control. In furtherance of this framework, we conduct research and development on detection and forensics technologies, characterize system performance, acquire and deploy detection systems, and support operational partners with the development of programs to effectively perform detection operations. To support the U.S. Government's (USG) attribution process, we focus on improving the readiness of the overarching USG forensic capabilities; advancing the technical capabilities to perform forensic analyses on pre-detonation nuclear and other radioactive materials; and building and sustaining an expertise pipeline for nuclear forensic scientists. These efforts, coupled with the work of interagency partners, will advance USG capabilities to detect and interdict a nuclear threat and hold accountable those who are responsible for such actions.

I. Introduction

Preventing nuclear terrorism is a top priority of national security for the U.S. Government (USG). 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"**[*1*]**. Terrorists and other affiliated groups that have expressed interest in acquiring and using a nuclear device continue to pose a risk to our national security.

To address the threat, the Domestic Nuclear Detection Office (DNDO) was established in 2005 within the U.S. Department of Homeland Security (DHS) with the mission of preventing nuclear terrorism **[*2*]**. In the decade since, DNDO, in coordination with other USG agencies, has significantly advanced our capabilities to detect nuclear and other radioactive material out of regulatory control and to conduct technical nuclear forensics to attribute nuclear events. We take

an enterprise-wide approach, working closely with federal, state, local, tribal, and territorial government partners. Recognizing that nuclear terrorism is a global threat **[*3*]**, DNDO, in coordination with other USG agencies, works with partner nations and international agencies to support nuclear security programs around the world. The contribution of stakeholders from the private sector, academia, and the National Laboratories is also vitally important to our success.

II. DNDO's Approach to Preventing Nuclear Terrorism

DNDO is responsible for developing—in coordination with the U.S. Departments of Defense (DoD), Energy (DOE), Justice (DOJ), and State (DOS), and the Office of the Director of National Intelligence (ODNI)—an enhanced global nuclear detection architecture and for implementing the domestic portion **[*2*]**. The global nuclear detection architecture is a framework for detecting, analyzing, and reporting on nuclear and other radioactive materials that are out of regulatory control. Working with partners, we conduct transformational research, development, testing, and evaluation of advanced detection technologies; measure detector system performance; and ensure effective response to detection alarms, among other activities.

In addition, DNDO provides centralized stewardship, planning, and integration for all federal nuclear forensics activities **[*4*]**. We are also responsible for ensuring an enduring pipeline of nuclear forensics expertise and for leading the development and implementation of the *National Strategic Five-Year Plan for Improving the Nuclear Forensics and Attribution Capabilities of the United States* **[*4*]**.

In both nuclear detection and forensics, we rely on the critical triad of intelligence, law enforcement, and technology. Thus, to maximize our nation's ability to detect and interdict a threat, it is imperative that we apply detection technologies in operations 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 USG must ensure that information from law enforcement, intelligence, and technical nuclear forensics is synthesized to identify the origin of the material or device, and the perpetrators.

III. Developing the Global Nuclear Detection Architecture

With respect to nuclear detection, our strategy is based on a defense-in-depth framework. Our objective is to make prohibitively difficult the illicit acquisition, fabrication, and transport of a nuclear or radiological device or material. By presenting adversaries with many obstacles to illicit activities, the USG greatly increases the adversary's cost, difficulty, and risk. This is accomplished—in part—through a multi-faceted, multi-layered arrangement of both fixed and mobile equipment for detecting radiation in the United States and abroad.

To develop a *global* nuclear detection architecture, we must rely on the decisions of sovereign foreign partners regarding their own national-level nuclear detection architectures and regional detection programs. To support these efforts, we collaborate with interagency partners at DoD, DOE, and DOS, with international partners, and through multi-lateral groups, such as the Global Initiative to Combat Nuclear Terrorism, the International Atomic Energy Agency (IAEA), and the International Law Enforcement Academy. As an example, DNDO led the development of the four-volume *Developing a Nuclear Detection Architecture* series of guidelines and best practices **[*5*]** that the IAEA is publishing as part of its Nuclear Security Series as guidance for all 163 Member States. The IAEA also uses this guidance for regional and international training courses

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to help nations develop and enhance their national-level detection architectures. Our efforts abroad help bring together the international community working on nuclear detection.

IV. Implementing the Domestic Component

To implement the domestic component of the global nuclear detection architecture, we assist operational partners as they develop local and regional capabilities. In some instances, particularly in support of DHS operational partners, we acquire and deploy radiation detection systems.

Our collaborative efforts in acquiring systems have ensured that all U.S. Coast Guard boarding parties carry radiation detection equipment; all incoming general aviation flights are met by U.S. Customs and Border Protection officers with radiation detectors; 100% of truck-borne containerized cargo and personally owned vehicles entering the United States at land ports of entry are scanned for nuclear and other radioactive materials; almost 100% of maritime containerized cargo is similarly scanned at sea ports of entry; and the Transportation Security Administration's Visible Intermodal Prevention and Response teams are equipped with radiation detectors. While the acquisition and deployment of detection technology is critical, the training, exercises, and cross-jurisdictional protocols that operational partners adopt and sustain are integral to mission success.

Accordingly, we also provide program assistance services to state, local, and tribal agencies that are developing or enhancing their capabilities for radiation detection. This support includes assistance in establishing and integrating local or regional programs into the global nuclear detection architecture, guiding the development of concepts of operations and standard operating procedures, and training and exercising to instill those procedures into day-to-day activities.

One such effort, focused on urban areas, is the Securing the Cities program. Through this program, DNDO seeks to reduce the threat against major metropolitan areas in the United States posed by illicit nuclear or other radioactive materials. Once fully implemented, the program's capabilities will extend to nearly 100 million people, over 34% of the Nation's GDP and 42% of our critical infrastructure. We provide Securing the Cities funds and federal assistance to high-threat, high-density urban areas to establish or enhance a regional preventive radiological and nuclear detection program. State and local partners use Securing the Cities funds to procure equipment, and we assist by conducting training and exercises to strengthen capabilities and enhance coordination with federal operations. So far, more than 19,450 personnel have been trained in nuclear detection operations and more than 8,800 pieces of detection equipment have been deployed in the New York/Newark/Jersey City area, where the program began. Today, the program is also being implemented in the Los Angeles/Long Beach area and the National Capital Region.

In the day-to-day work of a first responder, illicit radiological or nuclear incidents are rare. Thus training, exercises, and assessments are particularly important to keep operators ready to react effectively should the need arise. This is where DNDO brings to bear a unique Red Team capability that can challenge our operational partners with uncommon nuclear sources and scenarios. The Red Team evaluates deployed systems and operations and their associated tactics, techniques, and procedures, in environments that are as close to realistic as possible. This provides valuable feedback, helping operators improve their concepts of operation and readiness.

To augment federal, state, and local capabilities during special events—or in response to elevated threat conditions—we deploy Mobile Detection Deployment Units with equipment for

radiological and nuclear detection and for communication. These units are also available to our state and local partners seeking to exercise their radiation detection operations. Each unit is configured to outfit numerous personnel and contains detection systems including wide-area search backpacks, high-resolution handheld devices, personal radiation detection devices, and equipment for tracking and communication. When deployed, the unit is accompanied by technical support staff to train federal, state, and local personnel on the use of equipment and to help integrate these surge capabilities into other protective operations.

V. Transformational Research and Development

To make dramatic advancements in technologies for nuclear material detection and technical forensics capabilities, DNDO conducts aggressive, evolutionary, and transformational research and development. We advance fundamental knowledge in these areas through sustained long-term investment in research and development. In addition, these efforts also seek to reduce the cost and operational burden of using technology in the field.

DNDO's Academic Research Initiative leverages the capabilities of universities to develop the next generation of scientists and engineers in areas such as advanced materials, nuclear engineering, radiochemistry, and deterrence theory. Since the initiative's inception, grants have been awarded to more than 50 academic institutions across the country, and these projects are beginning to have real-world applicability. For example, nuclear resonance cross sections measured at Duke University are used in DNDO-sponsored detection projects for shielded special nuclear material, and high-fidelity radiation background measurements performed at the University of California at Berkeley are used by the National Laboratories to link radiation measurements to specific points in environments with buildings, roadways, overpasses, and walls.

Several DNDO-sponsored research efforts have also led to new commercial products. For instance, we have transitioned advanced radiation sensing materials—such as cesium lithium yttrium chloride, strontium iodide, and stilbene—from the National Laboratories to industry. These materials have enhanced detection characteristics and can be used to build more capable systems featuring simplified electronics, low power requirements, and greater reliability. Until recently, stilbene was available only through suppliers from Ukraine. With DNDO's support, stilbene is now being produced domestically at lower cost and in greater quantities. Our research and development efforts will steadily advance technologies to detect nuclear and radiological threats.

VI. Characterizing System Performance

DNDO's efforts in technology development are coupled with a rigorous test and evaluation program. We have conducted more than 100 test and evaluation campaigns at more than 40 laboratory and operational venues. To ensure the equipment is evaluated in the manner in which it will be used, these test campaigns are always planned and executed with operational users. The results from our test campaigns have informed federal, state, local, and tribal partners on the technical and operational performance of detection systems, allowing them to select the most suitable equipment and implement the most effective concepts of operation for their unique needs.

DNDO leads the development of technical capability standards, and, in collaboration with the National Institute of Standards and Technology, we also support the development, publication, and adoption of national consensus standards for radiation detection equipment. A total of 24 standards—including 11 U.S. standards with the American National Standards Institute **[*6*]**, 10

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international standards with the International Electrotechnical Commission **[*7*]**, and three technical capability standards—now exist for homeland security applications **[*8*]**. We have assessed commercially available detection systems against national and international standards and in various operational scenarios. Notably, we completed the Illicit Trafficking Radiation Assessment Program, a collaboration with the European Commission's Joint Research Centre and the IAEA, to evaluate nearly 80 instruments against consensus standards. The results enabled our stakeholders to compare the performance of commercially available radiation detection equipment and provided manufacturers with constructive feedback on their products.

VII. Nuclear Forensics Capabilities

The United States is committed to "hold fully accountable any state, terrorist group, or other non-state actor that supports or enables terrorist efforts to obtain or use weapons of mass destruction" **[*9*]**. This commitment is made possible by our ability to identify perpetrators through information gained from nuclear forensics, intelligence, and law enforcement. Such information should serve as a strong deterrent to terrorist accomplices and, especially, to potential state sponsors of terrorism.

To ensure that sound scientific evidence bolsters that commitment, DNDO focuses on improving the readiness of the overarching USG nuclear forensic capabilities; advancing our technical capabilities to perform forensic analyses on pre-detonation nuclear and other radioactive materials; and building and sustaining an expertise pipeline for nuclear forensic scientists **[*4*]**.

We have helped lead realistic and complex forensic exercises, with intensive multiagency planning, among the Department of Justice/Federal Bureau of Investigation, DOE, and the DoD. Many of the exercises include state and local law enforcement. Others have involved the intelligence community, in order to plan and synchronize the fusion of intelligence, law enforcement, and technical forensics information—leading to more efficient and effective processes.

We also work to improve the accuracy, precision, and timeliness of information on characterizing material, and we link that information to the process and place of that material's origin. As one example, we have developed the first-ever laboratory-scale uranium processing capability, allowing the USG to determine forensic signatures associated with specific variations in processes of manufacturing uranium. This capability enables the determination of forensics signatures without having direct access to samples from foreign fuel cycles. We are beginning to develop a similar plutonium-processing capability. Along with other DNDO-sponsored projects, we are significantly improving the nation's ability to trace nuclear materials back to their source.

To address a gap in human capital needs in the nuclear forensics field, the National Nuclear Forensics Expertise Development Program was established as the comprehensive USG effort to grow and sustain qualified technical expertise. Launched in 2008, this program is a key component for ensuring a robust, enduring capability in nuclear forensics. In close partnership with 11 National Laboratories, the program has provided support to more than 300 students and faculty and 27 universities. We have exceeded the metric established in 2008 of adding 35 new PhD scientists to the field of nuclear forensics by 2018, revitalizing the pipeline and replacing anticipated attrition or retirements from the DOE National Laboratories. Since the program began, thirty-seven new nuclear forensics scientists have been supported and hired by the National Laboratories and federal agencies.

VIII. Conclusion

To guard against the danger of nuclear terrorism, our nation takes a comprehensive, defense-in-depth approach to detection and an integrated approach to nuclear forensics. Along with our partners, DNDO is committed to developing and evolving robust national capabilities to ensure that would-be nuclear terrorists face numerous hurdles to success. To that end, we will continue to strengthen the technical and operational capabilities of our mission partners to detect nuclear and other radioactive materials out of regulatory control and to hold accountable those who threaten the security of our nation.

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X. Authors' Bios and Contact Information

Dr. Huban A. Gowadia - On September 20th, 2013, President Obama appointed Dr. Huban A. Gowadia as the Director of the U.S. Department of Homeland Security's Domestic Nuclear Detection Office (DNDO). Under her leadership, DNDO develops nuclear detection capabilities,

measures detector system performance, ensures effective response to detection alarms, conducts transformational research and development, and coordinates the improvement of technical nuclear forensics capabilities across the U.S. Government. Prior to this role, Dr. Gowadia served at DNDO as the Acting Director from 2012 to 2013, Deputy Director from 2010 to 2012, Assistant Director of the Mission Management Directorate from 2007 to 2010, and Assistant Director for Assessments from 2005 to 2007. Before joining DNDO, Dr. Gowadia led DHS's Science & Technology Countermeasures Test Beds as Program Executive from 2003 to 2005. Dr. Gowadia also worked as Checkpoint Program Manager in the Office of Security Technologies in the Transportation Security Administration (TSA) from 2001 to 2003. She previously served with the Federal Aviation Administration at the Aviation Security Laboratory from 2000 to 2001. Dr. Gowadia received a Bachelor of Science degree in Aerospace Engineering from the University of Alabama and a Ph.D. in Mechanical Engineering from the Pennsylvania State University. Contact: DNDO.info@hq.dhs.gov

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