Prevent, Counter, and Respond—A Strategic Plan to Reduce Global Nuclear Threats

FY 2018–FY 2022

Report to Congress
November 2017

National Nuclear Security Administration
United States Department of Energy
Washington, DC 20585

Message from the Administrator

The Department of Energy's (DOE) National Nuclear Security Administration (NNSA) Fiscal Year 2018 report, *Prevent, Counter, and Respond—A Strategic Plan to Reduce Global Nuclear Threats*, outlines DOE/NNSA's plans and programs to prevent the proliferation of nuclear weapons, counter the threat of nuclear terrorism, and respond to nuclear and radiological incidents around the world. The report is a companion to the Fiscal Year 2018 *Stockpile Stewardship and Management Plan*, which describes DOE/NNSA's activities to ensure the reliability of the U.S. nuclear stockpile and maintain its foundational capabilities and infrastructure. In keeping with our commitment to transparency, updated versions of these reports are published each year.

Maintaining the U.S. nuclear stockpile and reducing global nuclear threats—two missions that are often thought to involve different technical expertise and pursue disparate goals—are far more interconnected than they may appear. Many activities within these two DOE/NNSA mission pillars are mutually reinforcing and supportive of common objectives. The facilities and scientific knowledge that underpin stockpile stewardship, for example, are harnessed for a range of nonproliferation and counterterrorism missions, from assessing foreign weapons programs and potential terrorist devices to managing the proliferation risks posed by civil nuclear applications. Preventing the spread of nuclear weapons around the world yields considerable benefits for the U.S. nuclear posture. By limiting the number of nuclear-capable states and preventing terrorist access to materials and technology that can threaten the United States and its allies, global stability is broadly enhanced and the range of potential threats facing the nation is thereby constrained.

DOE/NNSA's nonproliferation and counterterrorism activities extend the nation's defenses far beyond America's borders. The United States' long experience in securing special nuclear materials is being shared with partners around the world in ways that promote international nonproliferation and counterterrorism efforts. Similarly, DOE's national laboratories and production plants, leveraging stockpile-related facilities and knowledge, provide nuclear safeguards training and technology to International Atomic Energy Agency inspectors to help detect diversion of nuclear materials and verify the peaceful use of nuclear energy.

The *Prevent, Counter, and Respond* report describes how DOE/NNSA's nonproliferation, counterterrorism, and emergency response programs apply the scientific and technical capabilities and highly-skilled workforce of the nuclear security enterprise to execute critical national security missions. The report also underscores the necessity of repairing and recapitalizing DOE/NNSA's aging infrastructure, some of which dates to the Manhattan Project era. Providing quality workspace to DOE/NNSA's workforce is crucial to recruiting and retaining the world-class talent on which our nuclear threat reduction missions depend.

This report addresses the requirement in 50 U.S.C. § 2575—which was added by Section 3132 of the *FY 2016 National Defense Authorization Act*—for DOE/NNSA to produce a *Defense Nuclear Nonproliferation Management Plan*. This report, along with a separate classified annex, is provided to the following Members of Congress:

- **The Honorable John McCain**
  Chairman, Senate Committee on Armed Services
- **The Honorable Jack Reed**
  Ranking Member, Senate Committee on Armed Services

- **The Honorable William "Mac" Thornberry**
  Chairman, House Committee on Armed Services
- **The Honorable Adam Smith**
  Ranking Member, House Committee on Armed Services
- **The Honorable Bob Corker**
  Chairman, Senate Committee on Foreign Relations
- **The Honorable Ben Cardin**
  Ranking Member, Senate Committee on Foreign Relations
- **The Honorable Edward R. Royce**
  Chairman, House Committee on Foreign Affairs
- **The Honorable Eliot L. Engel**
  Ranking Member, House Committee on Foreign Affairs
- **The Honorable Thad Cochran**
  Chairman, Senate Committee on Appropriations
- **The Honorable Patrick Leahy**
  Vice Chairman, Senate Committee on Appropriations
- **The Honorable Lamar Alexander**
  Chairman, Subcommittee on Energy and Water Development
  Senate Committee on Appropriations
- **The Honorable Dianne Feinstein**
  Ranking Member, Subcommittee on Energy and Water Development
  Senate Committee on Appropriations
- **The Honorable Rodney P. Frelinghuysen**
  Chairman, House Committee on Appropriations
- **The Honorable Nita M. Lowey**
  Ranking Member, House Committee on Appropriations
- **The Honorable Michael K. Simpson**
  Chairman, Subcommittee on Energy and Water Development
  House Committee on Appropriations
- **The Honorable Marcy Kaptur**
  Ranking Member, Subcommittee on Energy and Water Development
  House Committee on Appropriations

If you have questions about this plan, please contact me or Nora F. Khalil, Associate Administrator for External Affairs, at (202) 586-7332.

Sincerely,

Frank G. Klotz

Message from the Secretary

Among the Department of Energy's (DOE) most solemn responsibilities are the jobs of keeping the American people safe from global nuclear threats and ensuring the peaceful use of nuclear energy. This report describes the Department's central role in the international effort to reduce nuclear and radiological dangers, chiefly performed through the work of DOE's National Nuclear Security Administration (NNSA). In particular, this report details the "prevent-counter-respond" framework for establishing a defense-in-depth strategy against current and emerging nuclear threats.

At DOE, we strive to ***prevent*** terrorists and proliferant states from developing nuclear weapons or obtaining weapons-usable materials and technology. We ***counter*** efforts by both groups to acquire or develop these capabilities. And we prepare to ***respond*** to nuclear incidents whenever and wherever they occur. This model, part of a whole-of-government approach to reducing nuclear dangers, reflects our best understanding of the nuclear threat and the means to address it. The Department, in close cooperation with its interagency partners, continuously monitors the international security landscape to ensure the United States adapts to shifting threats, evolving technologies, and other developments that may imperil U.S. security.

Our task to reduce the threat is not without challenges. For instance, nuclear and radiological materials residing in regions of concern along with stockpiles of weapons-usable nuclear materials around the world will require increased and constant security. Growing worldwide interest in civil nuclear power and associated facilities will require greater attention to countering potential nuclear proliferation and terrorism dangers. Furthermore, new technologies and manufacturing processes are emerging which have possible nuclear proliferation consequences that must be addressed.

We conduct this essential work against the backdrop of a range of geopolitical developments, not least of which is the existence of significant terrorist activity around the world. The expanding volume of global trade, together with the growing sophistication of illicit procurement networks and diffusion of knowledge on the internet, dictate that we work diligently to prevent malevolent actors from acquiring nuclear materials and technology. Each of these developments may disrupt traditional approaches to nonproliferation and counterterrorism, requiring constant agility to respond to nuclear threats.

The scientific expertise resident in DOE/NNSA's national laboratories, production plants, and other sites is a national treasure and indispensable to the nation's efforts to prevent, counter, and respond to nuclear threats. Ensuring that the nuclear security enterprise has the resources, modern facilities, and intellectual capital needed to perform these vital missions is among the highest priorities of this Department. The Department will continue to protect the nation, as it has for decades, by executing a comprehensive strategy that integrates provision of a safe, secure, and effective nuclear stockpile with focused actions to prevent, counter, and respond to nuclear threats across the spectrum.

Sincerely,

Rick Perry

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Executive Summary

For nearly six decades, the United States, working with its allies and the broader international community, has pursued a global strategy to reduce dangers to the Nation from the spread of nuclear weapons and from nuclear and radiological terrorism. Events over the past ten years – including North Korea's nuclear tests and incidents involving the unauthorized possession of nuclear material or radioactive sources[1] – have demonstrated the threat posed by U.S. adversaries and terrorist groups seeking a nuclear weapons capability. Such malevolent actors continue to demonstrate interest in acquiring nuclear and radiological materials, and the persistence of regional conflicts weaken a state's ability to protect these materials from theft or diversion. Moreover, rapidly changing technologies (e.g., additive manufacturing, powerful computer-aided design applications, and cyber-attack tools) and greater diffusion of dual-use knowledge may provide proliferators with easier acquisition pathways to nuclear weapons capabilities.

To meet these challenges, the Department of Energy's National Nuclear Security Administration (DOE/NNSA) plays a key role in nuclear threat reduction and centers its approach around three pillars:

- **Prevent** non-state actors and proliferant states from developing nuclear weapons or acquiring weapons-usable nuclear material, equipment, technology, and expertise and prevent non-state actors from acquiring nuclear and radiological materials for an improvised nuclear device (IND) or radiological dispersal device (RDD) (Chapter 2);
- **Counter** the attempts of both proliferant states and non-state actors to steal, acquire, develop, disseminate, transport, or deliver the materials, expertise, or components necessary for a nuclear weapon, IND, or RDD (Chapter 3); and,
- **Respond** to nuclear or radiological incidents by searching for and rendering safe threat devices and materials; carrying out nuclear forensic activities; conducting consequence management actions following an event to protect lives, property, and the environment; and preparing for and supporting departmental emergencies through close coordination with the Department's Emergency Management Enterprise system (Chapter 4).

This document, *Prevent, Counter, and Respond—A Strategic Plan to Reduce Global Nuclear Threats (FY 2018–FY 2022) (NPCR)* and its classified appendix, describes DOE/NNSA's strategic management approach to fulfill its nuclear threat reduction mission within a complex global nuclear security environment. The NPCR explains how NNSA prioritizes its programmatic response to nuclear security threats, outlines the program plans and resources applied to each of these pillars over the next five years, and discusses the challenges faced by DOE/NNSA as it executes nuclear nonproliferation, counterterrorism, counterproliferation, and incident response plans. Additionally, the NPCR describes how the DOE/NNSA nuclear security enterprise of national laboratories, production facilities, and sites provide the vital and necessary tools, knowledge, and infrastructure to implement DOE/NNSA's strategies and programs in the foregoing areas, including its work with key international partners and institutions.

The NPCR is a companion to the *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, which describes DOE/NNSA's activities to ensure the reliability and maintain the foundational capabilities and infrastructure of the U.S. nuclear stockpile. Despite differing technical expertise and goals, the

[1] IAEA GOV/2017/31-GC(61)/14, *Nuclear Security Report 2017* (Vienna, Austria: International Atomic Energy Agency, July 25, 2017)

maintenance of the U.S. nuclear stockpile and the reduction of global nuclear threats are far more interconnected than they may appear. The facilities and scientific knowledge that underpin stockpile stewardship, for example, are harnessed for a range of nonproliferation and counterterrorism missions, from assessing foreign weapons programs and potential terrorist devices to managing the proliferation risks posed by civil nuclear applications. Preventing the spread of nuclear weapons around the world yields considerable benefits for the U.S. nuclear posture. By limiting the number of nuclear-capable states and preventing terrorist access to nuclear and radiological materials and technology, global stability is broadly enhanced and the range of potential threats facing the Nation is thereby constrained.

DOE/NNSA is committed to adapting its nuclear threat reduction objectives to address emerging global nuclear trends and dynamic threats. The scientific and technical capabilities and highly-skilled workforce of the nuclear security enterprise support DOE/NNSA's nonproliferation, counterterrorism, counterproliferation, and emergency response programs in executing their critical national security missions. Through its facilities, technical expertise and long experience in handling nuclear materials, DOE/NNSA remains central to U.S. and international efforts to develop and implement domestic and international programs and strategies to prevent the unauthorized acquisition of nuclear and radiological materials, counter any attempts to do so, and respond effectively to nuclear or radiological incidents.

Prevent, Counter, and Respond—A Strategic Plan for Reducing Global Nuclear Threats (FY 2018–FY 2022)

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List of Acronyms

ANL	Argonne National Laboratory
ARG	Accident Response Group
BNL	Brookhaven National Laboratory
BSAP	Bulk Special Nuclear Material Analysis Program
CBRN	Chemical, Biological, Radiological, and Nuclear
CFR	Code of Federal Regulations
COE	Center of Excellence
COG	Continuity of Government
COOP	Continuity of Operations
CPIC	Capital Planning & Investment Control
CTBT	Comprehensive Nuclear-Test-Ban Treaty
CTBTO Prepcom	Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization
CTCP	Office of Counterterrorism and Counterproliferation
CTSD	Counterterrorism Security Dialogue
CWC	Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (Chemical Weapons Convention)
DFEAT	Disposition and Forensic Evidence Analysis Team
DFO	DOE Forensics Operation
DHS	Department of Homeland Security
DNN	Office of Defense Nuclear Nonproliferation
DNN R&D	DNN Office of Research and Development
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOJ	Department of Justice
DOS	Department of State
DTRA	Defense Threat Reduction Agency
ECN	Emergency Communications Network
EIMC	Emergency Incident Management Council
EPA	Environmental Protection Agency
EURATOM	European Atomic Energy Community
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FTE	Full-Time Equivalent
G7	Group of Seven (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States)
GBD	Global Burst Detector
GMS	Office of Global Material Security
GPS	Global Positioning System

HAMMER	Hazardous Materials Management and Emergency Response
HEU	Highly Enriched Uranium
HHS	Department of Health and Human Services
IAEA	International Atomic Energy Agency
IDC	International Data Centre
IEMC	International Emergency Management and Cooperation
IMP&C	International Material Protection and Cooperation
IMS	International Monitoring System
IND	Improvised Nuclear Device
INF	Intermediate-Range Nuclear Forces
INFCIRC	IAEA Information Circular
INL	Idaho National Laboratory
IUP	Integrated University Program
JASPER	Joint Actinide Shock Physics Experiment Research
JCPOA	Joint Comprehensive Plan of Action
JEV	Joint Expert Familiarization Visit
KCNSC	Kansas City National Security Campus
kg	kilograms
LANL	Los Alamos National Laboratory
LEU	Low-Enriched Uranium
LLNL	Lawrence Livermore National Laboratory
LTBT	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (Limited Nuclear Test Ban Treaty)
M^3	Office of Material Management and Minimization
M&O	Management and Operations
MAP	Master Asset Plan
Mo-99	Molybdenum-99
MOX	Mixed Oxide
MT	Metric Tons
MTR	Materials Testing Reactor
NARAC	National Atmospheric Release Advisory Center
NATO	North Atlantic Treaty Organization
NCT	Nuclear Counterterrorism
NCTIR	Nuclear Counterterrorism and Incident Response
New START	Treaty Between the United States of America and the Russian Federation on Measures for Further Reduction and Limitation of Strategic Offensives Arms (New Strategic Arms Reduction Treaty)
NGFP	NNSA Graduate Fellowship Program
NGSI	Next Generation Safeguards Initiative
NLDC	National Laboratory Directors Council
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site

NPAC	Office of Nonproliferation and Arms Control
NPT	Treaty on the Non-proliferation of Nuclear Weapons (Nuclear Non-Proliferation Treaty)
NRAT	Nuclear/Radiological Advisory Team
NRC	Nuclear Regulatory Commission
NSDD	Office of Nuclear Smuggling Detection and Deterrence
NSG	Nuclear Suppliers Group
NSPD	National Security Presidential Directive
NTR	Nuclear Threat Reduction
NuDet	Nuclear Detonation
OCONUS	Outside the Continental United States
OLEM	On-Line Enrichment Monitor
OPCW	Organization for the Prohibition of Chemical Weapons
ORNL	Oak Ridge National Laboratory
ORS	Office of Radiological Security
OSI	On-Site Inspection
OSRP	Off-Site Source Recovery Program
P3	France, the United Kingdom, and the United States
PD	Office of Proliferation Detection
PMDA	Agreement between the Government of the United States of America and the Government of the Russian Federation Concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes and Related Cooperation (U.S.-Russia Plutonium Management and Disposition Agreement)
PNNL	Pacific Northwest National Laboratory
PPD	Presidential Policy Directive
PPRA	Agreement between the Government of the United States of America and the Government of the Russian Federation Concerning Cooperation Regarding Plutonium Production Reactors (U.S.-Russian Federation Plutonium Production Reactor Agreement)
PWG	Plutonium Disposition Working Group
RAP	Radiological Assistance Program
RDD	Radiological Dispersal Device
SABRS-3	Space and Atmospheric Burst Reporting System–3
SBIR/STTR	Small Business Innovative Research/Small Business Technology Transfer
SENSER	Space and Endoatmospheric NuDet Surveillance Experimentation and Risk Reduction
SMU	Special Mission Unit
SNL	Sandia National Laboratories
SNM	Special Nuclear Material
SNSTC	[China's] State Nuclear Security Technology Center
SPARCS	Spectral Advanced Radiological Computer System
SPE	Source Physics Experiment
SRS	Savannah River Site
SSMP	Stockpile Stewardship and Management Plan
SSP	Stockpile Stewardship Program

ST&E	Science, Technology, and Engineering
START	Treaty between the United States of America and the Union of Soviet Socialist Republics on the Reduction and Limitation of Strategic Offensive Arms (Strategic Arms Reduction Treaty)
TRIGA	Test, Research, Isotopes, General Atomics – a type of U.S.-designed nuclear research reactor
TRL	Technology Readiness Level
TRNSO	Tactical Nuclear/Radiological Search Operation
TTBT	Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Underground Nuclear Weapon Tests (Threshold Nuclear Test Ban Treaty)
TTX	Tabletop Exercise
U-235	Uranium-235
UCS	Unified Coordination Structure
UK	United Kingdom
UN	United Nations
U.S.	United States
U.S.C.	United States Code
USD	U.S. dollar
USNDS	United States Nuclear detonation Detection System
USSR	Union of Soviet Socialist Republics
WIPP	Waste Isolation Pilot Plant
WMD	Weapons of Mass Destruction
WMD CT TTX	WMD Counterterrorism Tabletop Exercise
WUNM	Weapons-Usable Nuclear Material

Legislative Language

Title 50 of United States Code Section 2575 (50 U.S.C. § 2575), *Defense Nuclear Nonproliferation Management Plan*, requires that:

> *Concurrent with the submission to Congress of the budget of the President…in each fiscal year, the [NNSA] Administrator shall submit to the congressional defense committees a five-year management plan for activities associated with the defense nuclear nonproliferation programs of the Administration to prevent and counter the proliferation of materials, technology, equipment, and expertise related to nuclear and radiological weapons in order to minimize and address the risk of nuclear terrorism and the proliferation of such weapons.*

In addition, the report accompanying the 2017 Senate Energy and Water Development Appropriations Bill, S. 2804, directed NNSA to:

> *"… provide the Senate and House Appropriation Committees with a report that demonstrates how NNSA prioritizes threats to national security and links the budget request to those threats no later than June 30, 2017."*

The specific elements of the plan, and the location of the corresponding information within this document, are described in Appendix A

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Chapter 1: Introduction
Meeting the Challenges of Nuclear Proliferation & Terrorism

1.1 Overall Strategic Approach

Because of its world leadership in scientific and technical expertise and programmatic capabilities, the Department of Energy's (DOE) National Nuclear Security Administration (NNSA) plays a central U.S. Government role in fulfilling the nation's nuclear security strategy to:

(1) Dissuade states from pursuing nuclear weapons and deny adversaries from obtaining sensitive nuclear materials and technology, starting from their sources;

(2) Detect and disrupt an adversary's attempts to steal or produce a nuclear or radiological weapon; and

(3) Locate and defuse an emplaced nuclear or radiological device or, if a detonation occurs, to minimize and recover quickly from the damage as well as attribute responsibility for the incident.

One of DOE/NNSA's core mission pillars is nuclear threat reduction, described in DOE/NNSA's *Enterprise Strategic Vision* as "engaging countries and advancing capabilities to prevent, counter, and respond to nuclear and radiological proliferation and terrorism threats and incidents worldwide."

Figure 1. DOE/NNSA Mission Pillars and Crosscutting Capabilities

To execute this mission effectively within a global and dynamic threat environment, DOE/NNSA applies its nuclear nonproliferation, counterterrorism/counterproliferation, and emergency response capabilities across the entire nuclear threat spectrum—from the earliest stages of intent through post-event situations—by following three approaches:

1. **Prevent** non-state actors and proliferant states from developing nuclear weapons or acquiring weapons-usable nuclear material (WUNM), equipment, technology, and expertise and prevent non-state actors from acquiring nuclear and radiological materials for an improvised nuclear device (IND) or radiological dispersal device (RDD).
2. **Counter** the attempts of both proliferant states and non-state actors to steal, acquire, develop, disseminate, transport, or deliver the materials, expertise, or components necessary for a nuclear weapon, IND, or RDD.
3. **Respond** to nuclear or radiological incidents by searching for and rendering safe threat devices and materials; carrying out nuclear forensic activities; conducting consequence management actions following an event to protect lives, property, and the environment; and preparing for and supporting departmental emergencies through close coordination with the Department's Emergency Management Enterprise system.

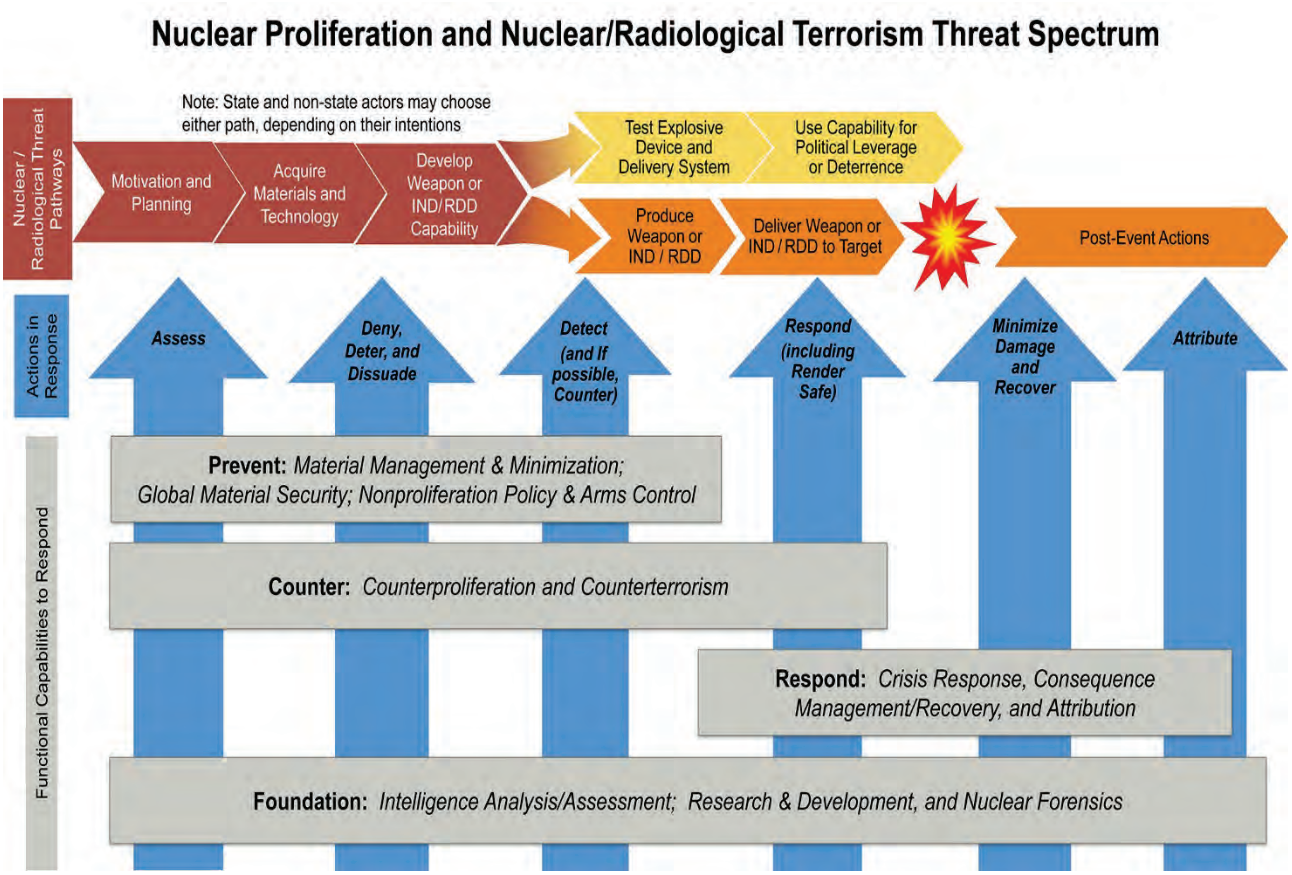

Figure 2. DOE/NNSA Strategic Approach to Countering Nuclear Proliferation and Terrorism

Through its prevent-counter-respond strategic approach, DOE/NNSA pursues the following objectives:

- Minimize and, when possible, eliminate excess WUNM, ensure sound management principles for remaining nuclear materials, and make available nuclear materials to encourage and support peaceful uses initiatives.
- Protect, control, and account for all nuclear and radiological materials worldwide (in accordance with internationally accepted recommendations) and prevent the illicit movement of nuclear material, other proliferation-sensitive materials, and radioactive sources.
- Prevent the proliferation of weapons of mass destruction (WMD)—including dual-use materials, equipment, technology, and expertise—by state and non-state actors through nuclear safeguards and export controls and by strengthening nonproliferation and arms control regimes.
- Develop effective technologies to detect foreign nuclear weapons proliferation and nuclear detonations and support monitoring and verification of foreign commitments to treaties and other international agreements and regimes.
- Strengthen nuclear counterterrorism and counterproliferation capabilities by pursuing scientific and technical activities to understand nuclear threat devices, designs, and concepts (including INDs) and to address risks arising from lost or stolen foreign nuclear weapons and their constituents (namely, nuclear and energetic materials).
- Reduce the terrorist value of nuclear or radiological weapons/devices by maintaining a nuclear and radiological emergency response capability to respond to, manage, avert, and contain the consequences of nuclear/radiological incidents in the United States or elsewhere in the world.
- Respond to nuclear or radiological terrorist threats by searching for and rendering safe threat devices, components, and/or nuclear and radiological materials and by conducting consequence management actions following an event to save lives, protect property and the environment, and meet basic human needs.
- Improve the emergency management system through an enterprise approach that effectively increases the Department's all-hazards emergency preparedness and response capability during complex, cascading, or enduring incidents and more effectively calls upon and leverages the assets, resources, and skills resident across DOE and the national laboratory complex.

In carrying out its Nuclear Threat Reduction (NTR) mission, DOE/NNSA works collaboratively with members of the U.S. Intelligence Community—including DOE's own Office of Intelligence and Counterintelligence—and other U.S. interagency partners, such as the Department of State (DOS), Department of Defense (DOD), Department of Homeland Security (DHS), and the Federal Bureau of Investigation (FBI).

1.2 Global Threat Environment and Trends

1.2.1 Persistent Threats

Among the greatest dangers facing the United States and its foreign allies is threat of a nuclear weapon being detonated by an adversary state or terrorist on the U.S. homeland or abroad, with its potentially catastrophic destruction and loss of life. There is a persistent threat of a U.S. adversary or terrorist group obtaining or developing a nuclear weapons capability. Accordingly, reducing the risk of nuclear weapons proliferating to other state and non-state actors has been a consistent U.S. national security policy goal for decades. This enduring U.S. nuclear nonproliferation and counter-nuclear terrorism policy is reflected in a number of U.S. public laws, and many bilateral, multilateral, and international agreements and instruments, including the *Atomic Energy Act of 1954,* the 1970 *Treaty on the Non-Proliferation of Nuclear Weapons* (NPT), the *Nuclear Non-Proliferation Act of 1978*, and the 1999 *National Nuclear Security Administration Act.* (See Appendix E for a list of the most significant instruments.)

As a result of actions by the United States, its allies, and the broader international community, the number of states that have developed or attempted to develop a nuclear weapons capability has been far fewer than many experts had predicted back at the beginning of the nuclear age. The United States and Russia have drastically reduced the size of their nuclear arsenals; the nuclear-weapons-capable infrastructure of several states (e.g., Iraq under Saddam Hussein, Libya under Muammar Gaddafi) has been dismantled; and the United States has led the international response to violations of the NPT by North Korea, Syria, and Iran. Perhaps most importantly, a set of global norms has emerged steadily over decades, in which any non-nuclear weapons state that attempts to acquire its own nuclear weapons capability is met with broad international disapproval.

Despite these positive achievements, there have been dangerous setbacks to the global nuclear nonproliferation regime. North Korea conducted six underground nuclear explosive tests between 2006 and 2017 in pursuit of nuclear weapons, while its nuclear complex continues to produce fissile material for more nuclear warheads. Iran's previous nuclear activities put it within months of being able to produce a nuclear weapon. India and Pakistan maintain and continue to develop their nuclear arsenals, and the threat of cross-border terrorism poses a risk to their region's stability.

In addition to nuclear weapons programs, the United States must also contend with the potential threat of a terrorist group acquiring or developing an IND or RDD and committing an act of nuclear or radiological terrorism. The al-Qaeda terrorist organization has openly stated its aspiration to acquire and use nuclear weapons and other WMD. Since the September 11, 2001 attacks, the increased international attention given to the prospect of nuclear and radiological terrorism has resulted in significant progress in mitigating the threat. Countries around the world have removed and eliminated nuclear material, strengthened nuclear security regulations, established domestic training and capacity-building programs to strengthen their nuclear security and protection capabilities, and increased cooperation to counter nuclear smuggling networks.

Thus far, no terrorist group has demonstrated significant progress toward acquiring or developing a nuclear weapon. But the risks of a nuclear or radiological terrorist attack still exist, and the United States must seek to deny terrorists the means of developing an IND. Inventories of nuclear and radiological materials continue to expand around the world, including in areas where physical protection and control systems may be insufficient or where terrorist groups operate nearby. The need to continue to remove and secure vulnerable nuclear and radiological material is underscored by the incidence of nuclear theft and smuggling activities. In 2016, the International Atomic Energy Agency (IAEA) continue to report on incidents involving unauthorized possession of and attempts to sell, purchase, or otherwise use nuclear material or radioactive sources for unauthorized purposes (although most of this was not WUNM, and in all of these incidents the material was seized and secured by local authorities).[2] Finally, the expanding availability of advanced technology and information is bringing the capability to construct an IND or RDD increasingly within reach of terrorists.

[2] IAEA *Nuclear Security Report 2017.*

1.2.2 Future Trends

The dynamic nature of global nuclear security threats and threat trends is a challenge to the existing nuclear nonproliferation and security architectures. DOE/NNSA's threat reduction programs will need to evolve in response to these developments. Key judgments on the nuclear threat environment are included in the classified appendix to this report, but several important trends consistent with those key judgments continue to characterize that environment:

- **Securing and managing nuclear and radiological materials will be challenged by the significant amounts of these materials around the world.** Working with international partners, DOE/NNSA has succeeded in converting (or verifying the shutdown of) over 90 research reactors and isotope production facilities worldwide to non-weapons usable nuclear materials, removing all highly-enriched uranium (HEU) material from 31 countries plus Taiwan and improving physical security at 221 facilities storing WUNM and more than 1,600 buildings with radioactive material. Whole regions of the world now no longer have HEU material within their territories. Yet the worldwide inventory of uranium and plutonium will continue to increase, as civilian nuclear power expands. This expansion, coupled with increasing access to nuclear technology, drives the need for improved material control and accounting processes, better security of fixed sites and nuclear materials transports, and more stringent regulatory control of nuclear materials that could end up in the hands of terrorists, proliferators, or criminals. While great strides have been made globally in consolidating, minimizing, and securing excess nuclear materials, excess stocks of HEU and separated plutonium continue to create special security risks. Additionally, many countries in the developing world are increasing their use of radiological source-based technologies to meet growing demands for improvements to healthcare and industrial capabilities. In this way, developing countries are taking more advantage of the benefits of the peaceful use of nuclear technology and radioactive sources, but security risks increase in parallel. Should countries or regions face internal strife and political instability that lead to weakened or failing state governance, the effective state control over these materials would be threatened. This dynamic of increased use of radioactive sources coupled with increased security risk is further complicated by the existence of illicit trafficking networks, which can exploit weaknesses in state governance, corruption, and the blurring of borders to smuggle stolen nuclear or radiological materials and technology. An agile security infrastructure is required to thwart such networks.

Figure 3. Old Russian Radioisotope Thermal Generators

- **Possessing nuclear weapons capabilities is likely to continue to be seen as a salient and desirable option for some states and non-state actors hostile to U.S. and allied interests, putting strains on monitoring, verifying, and maintaining arms control and nonproliferation regimes**. While the JCPOA constrains Iran's nuclear weapons capability, North Korea's pursuit of nuclear weapons shows that there are countries and groups still intent on possessing nuclear weapons, or having an option to do so. The possibility of regional use of nuclear weapons is a significant risk arising from this trend. Other risks may include complications for U.S. security relationships and of U.S.-led security policies and encouragement of further proliferation. Technological advances relevant to nuclear weapon design analysis, modeling, and manufacturing could weaken measures to detect covert nuclear weapons development programs and undermine confidence in monitoring and verification regimes. While no evidence exists today that terrorists possess nuclear material or weapons, the expanding availability of dual-use equipment, technology, and information increases the concern that terrorists could produce an IND if they were to also acquire sufficient WUNM.

- **The global expansion of civil nuclear power and the wide use of radioactive sources may accelerate the spread of dual-use technology and knowledge and increase demands on safety, security, safeguards, and emergency response systems.** Since the Fukushima Daichi nuclear power plant accident in March 2011, there has been a slowdown in anticipated global nuclear power reactor production. However, as Figure 4 shows, many states are still planning ambitious nuclear energy programs, and there continues to be a forecasted growth among "nuclear newcomers" (states that do not currently have civil nuclear power programs and therefore may lack experience in managing nuclear technologies, personnel, and incidents). For example, the United Arab Emirates continues construction of its first nuclear power reactor; Egypt and Turkey have signed contracts for nuclear power reactor construction; Bangladesh and Jordan have established nuclear operating companies in anticipation of launching their own national nuclear power programs; and Ghana, Kenya, Malaysia, Morocco, Saudi Arabia, and Sudan are actively considering whether to introduce nuclear power into their domestic energy infrastructure.[3] Some states seeking nuclear power have inadequate experience in safeguards and physical protection, regulatory infrastructures, and emergency management and nuclear incident response, which will place new burdens on the IAEA and others to supply assistance in these areas. The further spread of nuclear fuel cycle technologies, should it occur, would increase the strains on global nuclear security and safeguards systems. New reactor technologies and fuel cycles also may require new approaches in safety, security, safeguards, and emergency management, including measures to protect against terrorist acts such as sabotage or theft. Supplier competition from France, Russia, South Korea, and potentially China to service the growing global nuclear sector may stress export control regimes and escalate the diffusion of dual-use technology and information. Also, medical, agricultural, and other industrial advances may result

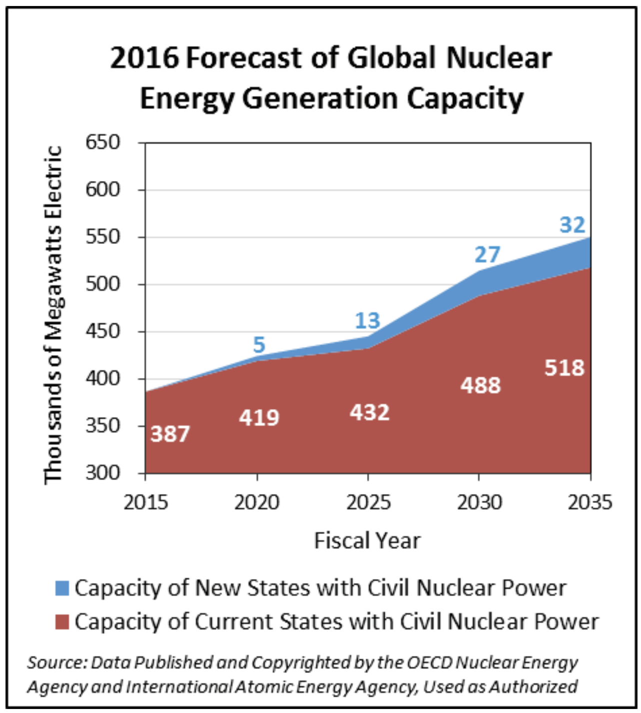

Figure 4. Projections for Global Civil Nuclear Power Growth

[3] International Atomic Energy Agency, *Annual Report 2015* (Vienna: IAEA, June 2016) pp 28-29.

in an expansion in the use and application of high-activity radioactive sources, especially in developing countries.

- **Expanding global trade volumes and sophistication of illicit procurement networks will increase the opportunities for state and non-state actors to acquire dual-use nuclear equipment and technology.** Expanding trade volumes will increase the export control, border monitoring, and law enforcement burdens on individual states and international/regional organizations (which continue to be under-resourced) to effectively combat the growing nonproliferation, counterterrorism, and emergency management challenges. A broad array of procurement networks will continue to seek increasingly sophisticated means to evade export controls, and should that extend to the nuclear/radiological trafficking realm, could increase proliferation, the destructive toolkit of terrorists, and the risks to public safety. Weak governance, corruption, blurring of borders within regions, possible ties between criminal and terrorist networks, and use of common network facilitators (e.g., financing and transportation) will be key enablers.
- **Rapidly changing technologies and greater diffusion of dual-use knowledge are expected to provide more ways for terrorists to threaten nuclear security systems and may also simplify acquisition pathways to nuclear weapons capabilities.** Scientific advances and manufacturing improvements (such as additive manufacturing and ever-more powerful computer-aided design applications) may create new and worrisome pathways to nuclear weapons. The wider availability and increased capabilities of cyber-attack tools in the hands of malevolent insiders, states, or non-state actors will make the security and safeguarding of nuclear and radiological facilities, and their associated networks, more vulnerable to attack (e.g., disabling security systems, falsifying material accounting balances, and unauthorized access to sensitive information). Further, the diffuse and decentralized nature of science and technology development, coupled with greater information connectivity, will increase the availability of sensitive information. Each of these changes may compromise traditional approaches to nonproliferation and presents additional security imperatives for the United States, not least of which is the need to anticipate technology surprise and to develop new policies rapidly in response to the impacts of these disruptive technologies.

Figure 5. Structure Produced Using Additive Manufacturing (Oak Ridge National Laboratory, TN)

1.3 Risk Assessment and Prioritization Approach

Congress supports the DOE/NNSA NTR mission through fiscal year funding under the Defense Nuclear Nonproliferation appropriation. This appropriation is divided into two parts: the Defense Nuclear Nonproliferation Program and the Nuclear Counterterrorism and Incident Response (NCTIR) Program. Each program office under the Defense Nuclear Nonproliferation fiscal-year appropriation has applied rigorous internal risk assessment and prioritization approaches to inform, develop, and provide the foundation for its fiscal year funding request. The FY 2016 realignment of the NCTIR Program under the

Apex Gold Scenario-Based Policy Discussion

On January 27–28, 2016, DOE, together with the Kingdom of the Netherlands' Ministry of Foreign Affairs, hosted a Scenario-Based Policy Discussion titled *Apex Gold*, with the following objectives: (1) Identify and discuss the strategic decisions and issues that senior government policymakers would need to address in a nuclear security threat, (2) Examine the critical role of technical information required for decision-making during a nuclear security event, (3) Exercise international notifications and international coordination required by a transnational nuclear security threat, and (4) Prepare for the Leader's Scenario-Based Policy Discussion at the 2016 Nuclear Security Summit in Washington, DC. Ministers and other senior delegates from 37 nations, along with representatives from the IAEA, Interpol, the European Union, and the United Nations, gathered at **Lawrence Livermore National Laboratory,** in Livermore, CA, to discuss effective national and international responses to a potential nuclear terrorist threat. In advance of the Scenario-Based Policy Discussion, the ministers and delegates were introduced to the technical capabilities that underpin radiation detection, nuclear forensics, and incident response and consequence management in order to better understand the technical tools available to support decision-making in the event of a nuclear security crisis.

Defense Nuclear Nonproliferation appropriation, the FY 2016 reorganization of the Office of Defense Nuclear Nonproliferation (DNN), as well as the transfer of incident response assets from the Office of Emergency Operations to the DOE/NNSA Office of Counterterrorism and Counterproliferation, provides DOE/NNSA with a more integrated structure for program planning, budgeting, and evaluation across the entire NTR mission space.

At the individual program level, the risk-informed prioritization process is directly influenced by U.S. policy imperatives, program management judgment, and a variety of other external factors. DOE/NNSA programs generally use classical risk assessment calculations (i.e., assessed threats, level of vulnerability, degree of consequences), which are tailored to their program-level missions and capabilities and influenced by external considerations (e.g., emergence or evolution of threat trends, time-urgency of a specific threat, windows of opportunity to act, level of long-term political support and cooperation from partners, adequacy of technical capabilities, and availability of resources).

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Chapter 2: Prevent
Preventing Nuclear/Radiological Proliferation and Terrorism

Prevent ***non-state actors and proliferant states from developing nuclear weapons or acquiring weapons-usable nuclear material, equipment, technology, and expertise, and to prevent non-state actors from acquiring nuclear and radiological materials for an improvised nuclear device or radiological dispersal device.***

DNN prevents the spread of nuclear weapons to other states or non-state actors by securing, safeguarding, and/or disposing of dangerous nuclear and radiological material, and by detecting and preventing the proliferation of related WMD technology and expertise. DNN programs actively use the science, technology, engineering, and manufacturing capabilities of the DOE/NNSA complex to solve the technical challenges of monitoring foreign weapons programs, verifying treaty compliance, and guarding against nuclear technological surprise. DNN also addresses the global nature of the nuclear threat by working closely with a wide range of international partners, key U.S. federal agencies, the DOE national laboratories, and the private sector. For example, DNN plays a central role in technical evaluation and implementation of the JCPOA as part of the interagency process working to hold Iran accountable for strictly enforcing its commitments under the deal, while meeting U.S. obligations.

DNN manages long-established DOE/NNSA programs responsible for fulfilling the U.S. statutory responsibilities over the export control requirements for nuclear technologies, as well as for fulfilling U.S. obligations under the NPT, primarily by providing funding, staffing, training, and technology to the IAEA for its nuclear safeguards inspectorate. These original DOE/NNSA nonproliferation programs also provide for the research and development of needed technologies, as well as technical support to U.S. policy development and implementation of strategic nuclear arms reduction treaties and other multilateral nuclear nonproliferation treaties and agreements.

DNN also manages many of the DOE/NNSA cooperative threat reduction programs created after the Soviet Union breakup to address the proliferation risks involving nuclear weapons, weapon-grade nuclear materials, and their storage facilities in former Soviet states. DNN programs have built on the experiences of these cooperative engagements to assist foreign partner countries in developing and maintaining a national-level nuclear security infrastructure that improves physical protection and site security practices, and supports the sustainability of U.S.-funded security upgrades.

After the September 11, 2001 attacks, DOE/NNSA's nonproliferation programs accelerated long-standing activities to minimize the global use and amounts of HEU and plutonium; improved security for, and disposition of, thousands of radioactive sources that could be used in RDDs; increased efforts to disrupt illicit nuclear/radiological material trafficking by deploying radiation detection monitors at foreign border crossings, seaports, and airports around the world; and increased research into new technologies, techniques, and materials to help prevent the spread of WMD to hostile countries or terrorist groups.

In light of a dynamic global nuclear security environment, DNN has aligned its program activities along functional lines, corresponding to mission areas that would be needed for at least the next decade, so as to provide a more flexible and responsive organizational framework capable of adapting to the evolving threat environment.

2.1 Material Management and Minimization

2.1.1 Program Strategy, Priorities, and Performance Metrics

M^3 seeks to minimize and eliminate excess weapons-usable nuclear materials and provide nuclear materials for peaceful uses.

The DNN Office of Material Management and Minimization (M^3) achieves permanent threat reduction by minimizing and, when possible, eliminating WUNM from civilian sites around the world. The integrated M^3 approach includes programs in three areas: HEU Reactor Conversion, Nuclear Material Removal, and Material Disposition.

A key starting point for material minimization is reducing demand for WUNM in civilian use. M^3 works around the world to convert or verify the shutdown of civilian research and test reactors and isotope production facilities that use or produce WUNM. In support of this work, M^3 also develops and qualifies new fuels and technologies to support reactor conversions. Additionally, M^3 supports international medical isotope producers to convert their production of molybdenum-99 (Mo-99) from the use of HEU to low-enriched uranium (LEU) targets, and accelerates the production of Mo-99 in the United States with non-HEU methods. These efforts result in permanent threat reduction by minimizing and, to the extent possible, eliminating the demand for HEU in civilian applications.

Once WUNM is no longer required at a facility, M^3 works with our international partners to remove or dispose of the excess HEU and plutonium, including by repatriating U.S.-origin HEU and LEU fuel to the United States (mostly from materials testing reactors [MTR] and Test, Research, Isotopes, General Atomics- [TRIGA]-type reactors), repatriating Russian-origin HEU to Russia, and removing or disposing of "gap material," which is HEU and separated plutonium that falls outside of the scope of the U.S.- and Russian-origin return programs. M^3 also maintains and exercises the capability to rapidly respond, when tasked, to support the denuclearization of any countries of concern, building on the experiences gained and infrastructure developed in past denuclearization initiatives (e.g., the 2004 effort in Libya).

Material returning to the United States will be incorporated into material management and disposition plans. One of the disposition pathways for plutonium returned from overseas is to dilute and dispose of the material. Additionally, one of the disposition paths for HEU is down-blending to high-assay LEU (19.75% uranium-235 [U-235]) as feedstock for LEU research reactors, isotope production targets, and the American Assured Fuel Supply. By making LEU available for partners looking to convert reactors and targets from HEU to LEU, M^3 closes the materials management loop that began with HEU-to-LEU reactor conversions.

The M^3 program prioritizes its work based on the following factors:

- **Material Attractiveness:** M^3 focuses its efforts on nuclear materials that could be used by state and non-state sponsors of terrorism to fabricate a nuclear weapon—HEU and plutonium. M^3 uses the DOE Categorization Chart (*DOE O 474.2 Chg 4, 9-13-16*) as a reference for categorizing nuclear material attractiveness. However, M3 considers other factors in addition to the chart to determine material attractiveness.
- **Internal Site Vulnerability:** M^3 also considers site security conditions. This information comes from a number of sources including formal assessments from DOE/NNSA's Office of Nonproliferation and Arms Control (NPAC), or the DOE Office of Intelligence and

Counterintelligence. Information may also come from informal M^3 assessments of security from site visits to implement its programs.

- **Country and Regional-Level Threat Environment:** M^3 also assesses the threat level in its partner countries and regions as part of its prioritization efforts. Data for country and regional-threat environments are derived from an assessment of terrorist presence, terrorist attacks, nuclear/radiological smuggling, nuclear/radiological thefts, and any other relevant information.
- **Technical Feasibility:** The technical feasibility of safely completing the conversion, removal, and/or disposition activity is also a contributing factor. Although a facility may be a high priority based on the previous three factors, M^3 will also take into account the technical feasibility of an activity when allocating resources to that effort. In accordance with the first factor (Material Attractiveness), M^3 will make it a priority to do the technical work necessary to complete these activities as soon as feasible.
- **Political Willingness:** The willingness of the partner country to cooperate in conversion, removal, and/or disposition activities also must be considered. M^3 works closely with interagency partners and the IAEA to obtain agreement to work at priority facilities as soon as possible.

M^3 regularly measures its performance in (a) the cumulative number of HEU reactors and isotope production facilities converted to LEU use or verified as shutdown, (b) the cumulative kilograms of vulnerable WUNM removed or disposed, (c) the cumulative amount of surplus U.S. HEU down-blended or shipped for down-blending, and (d) the cumulative kilograms of plutonium metal converted to oxide in preparation for disposition.

2.1.2 FY 2017 Activities, Accomplishments, and Challenges

Conversion

The **Conversion** program works to minimize, and to the extent possible, eliminate the use of HEU in research reactors and isotope production facilities worldwide in two programmatic areas: the Reactor Conversion subprogram and the Mo-99 subprogram.

The Reactor Conversion subprogram continues to convert the remaining HEU-fueled research reactors in Europe, Asia, Africa, and North America. A key part of this effort will be the successful qualification and commercial-scale fabrication of new high-density LEU fuels to convert high-performance research reactors in the United States and Europe that cannot be converted with existing LEU fuels.

The Mo-99 subprogram works to accelerate the establishment of reliable supplies of the medical isotope Mo-99 that are produced without the use of HEU. Under its long-standing HEU minimization mission, and consistent with Nuclear Security Summit commitments, the Mo-99 subprogram provides assistance to global medical isotope producers to eliminate the use of HEU at their production facilities located in Belgium, Canada, the Netherlands, and South Africa. The Mo-99 subprogram also works with U.S. commercial entities (via cooperative agreements funded on a 50-50 cost-share basis) to accelerate the establishment of new Mo-99 production in the United States without using HEU.

FY 2017 Accomplishments

- M^3 converted or verified the shutdown of three facilities currently using HEU.
- M^3 continued to support its cooperative agreement partners to establish a reliable commercial supply of Mo-99 produced without HEU, and assist global Mo-99 production facilities to eliminate the use of HEU targets by the end of 2018.

- M[3] continued to implement the Uranium Lease and Take-Back program in accordance with the *American Medical Isotopes Production Act of 2012*.
- M[3] supported the implementation of the JCPOA commitment to convert Iran's Arak Heavy Water Reactor.

Program Challenges

- Technical challenges related to producing new and unique fuel systems on a commercial scale for the conversion of high performance research reactors.
- Technical development of LEU targets and process chemistry needed for the conversion of the Mo-99 facilities located in Europe.
- Market forces within the commercial Mo-99 industry which have slowed customer uptake of LEU-based Mo-99 have delayed the process of fully converting to LEU targets.
- Financial challenges for some domestic Mo-99 partners to raise private (non-federal) funding.

Nuclear Material Removal

The **Nuclear Material Removal** program supports the removal and disposition of WUNM in three subprograms: U.S.-origin, Russian-origin, and Gap. Through these efforts, the Nuclear Material Removal program achieves permanent threat reduction by decreasing the number of proliferation-attractive targets, as well as the long-term equipment and personnel costs associated with securing WUNM. The Nuclear Material Removal program continues to support the removal of U.S.-origin HEU and LEU from eligible research reactors to the United States until the program ends in May 2019. For a limited number of countries, DOE/NNSA has provided an exemption to this deadline in cases where there is a national security or nonproliferation reason to do so.

The program is working closely with the Russian Federation to return Russian-origin WUNM from third countries under an ongoing Government-to-Government Agreement with Russia. The Nuclear Material Removal program also supports the removal or disposal of vulnerable, high-risk nuclear materials that are not covered by the Russian-origin and U.S.-origin subprograms. Referred to as "gap material," this

Figure 6. Removal of Last HEU from Poland – September 2016

includes U.S.-origin HEU not eligible under the U.S.-origin subprogram, non-U.S.-origin HEU, and separated plutonium.

Through its Emerging Threats subprogram, the Nuclear Material Removal program maintains and develops its capability to rapidly respond, when tasked, to support the denuclearization of any countries of concern, building on the experiences gained and infrastructure developed in past denuclearization initiatives (e.g., the 2004 effort in Libya).

FY 2017 Accomplishments

- M^3 removed or confirmed the disposition of 268.1 kilograms (kg) of HEU and/or plutonium in FY 2017, and exceeded its cumulative metric target of 6,285 kg.

Program Challenges

- Political challenges remain an obstacle to the removal of HEU and plutonium from certain countries.
- Technical challenges limit the types of nuclear material that can be brought back to the United States.

Material Disposition

The **Material Disposition** program is responsible for disposing surplus nuclear material through two subprograms: U.S. HEU disposition, including U.S. excess and repatriated U.S.-origin HEU, and U.S. Plutonium disposition. The HEU disposition subprogram down-blends HEU to LEU material (to 4.95% and to 19.75% U-235 enrichment levels) and manages the resulting LEU supply, making that material available for peaceful uses such as civilian reactor fuel, research reactor fuel, isotope production targets, and inventory for the American Assured Fuel Supply. The Plutonium disposition subprogram works toward fulfilling the United States' commitment to disposition 34 metric tons (MT) of surplus weapon-grade plutonium in a transparent manner, despite the Russian Federation's unilateral decision to suspend implementation of the U.S.-Russia Plutonium Management and Disposition Agreement (PMDA). The subprogram will also work toward dispositioning plutonium returned from overseas. Further, the subprogram works with international partners on technical plutonium management strategies to ensure that plutonium materials remain secure and out of the hands of terrorists and that plutonium stocks are reduced over time.

FY 2017 Accomplishments

- M^3 continued to support the U.S. commitment to plutonium disposition.
- M^3 dispositioned 3 MT of surplus HEU through down-blending to LEU, with a priority on legacy material to reduce risk.
- M^3 performed studies to optimize the final waste form of diluted plutonium, including optimizing container loading and material configuration at the repository.
- M^3 conducted environmental analyses to enable the disposition of diluted plutonium.
- M^3 continued discussions on plutonium management with non-Russian partners.

Program Challenges

- Consistent with congressional appropriations, the Material Disposition program is continuing construction activities on the mixed oxide (MOX) project to support the MOX fuel approach to plutonium disposition until a final decision to terminate the MOX project and begin the dilute and dispose approach is made. No program-level activities are being conducted. (For more discussion, see Section 2.5.1)

2.1.3 FY 2018 Future Years Program Plan

For FY 2018, M^3 will continue minimizing and, when possible, eliminating WUNM from civilian use around the world, through its Conversion, Nuclear Material Removal, and Material Disposition programs.

Main Areas of Program Activity for FY 2018

- Remove or confirm the disposition of 214 kg of HEU and/or plutonium material in FY 2018, for a cumulative total of 6,499 kg.
- Convert or verify the shutdown of one HEU research reactor and two isotope production facilities, for a cumulative total of 104 facilities converted or verified as shutdown.
- Work with China, as co-chair of the Arak Working Group of the JCPOA Joint Commission, to develop the technical basis and timeline for conversion of Iran's Arak research reactor.
- Provide technical and financial support to the U.S. private sector to accelerate the establishment of a reliable domestic production capability for Mo-99 without the use of HEU, and provide support to existing global Mo-99 producers to convert from the use of HEU to LEU.
- Begin key irradiation tests to down-select a fabrication capability and obtain final qualification data for high-density LEU fuel to convert U.S. high performance research reactors.
- Complete the lifecycle estimate for the dilute and dispose strategy for U.S. surplus weapon-grade plutonium.
- Continue to disassemble surplus U.S. nuclear weapon pits and convert the resulting plutonium metal into plutonium oxide powder.
- Continue to down-blend U.S. surplus HEU into LEU for peaceful use as fuel for commercial or research reactors, reaching a cumulative total of 160 MT of surplus HEU down-blended or shipped for down-blending by FY 2018.

Approaches to Address Program Challenges

- Continue to work with stakeholders to address concerns and overcome challenges on the Conversion, Nuclear Material Removal, and Material Disposition programs.
- Maintain comprehensive risk and quality assurance programs to mitigate technical challenges in the qualification and commercialization of new LEU research reactor fuels.
- Continue to work with the U.S. interagency, international partners, and industry on actions to promote the uptake of non-HEU-based Mo-99.
- Continue to work closely with the U.S. interagency, international partners, and the IAEA to obtain agreement to remove vulnerable nuclear material from priority facilities.
- Work with foreign counterparts and U.S. technical experts to assess alternate disposition pathways for material that cannot be returned to the United States.
- Continue to develop the program risks and a lifecycle cost estimate and schedule for the dilute and dispose alternative approach for surplus plutonium disposition.

2.2 Global Material Security

2.2.1 Program Strategy, Priorities, and Performance Metrics

GMS works with partners worldwide to (1) secure nuclear and radiological materials, and (2) interdict and investigate the trafficking of those weapons and materials.

To prevent terrorists from obtaining nuclear and radiological materials, the DNN Office of Global Material Security (GMS) strengthens partner capacity and commitment to secure these materials at their sources or in transit and to detect these materials when they have moved outside regulatory control. GMS provides nuclear and radiological security upgrades and related training, and strengthens supporting regulations, inspections, and security culture. GMS provides significant support to the IAEA to further that agency's nuclear security guidance documents and training and supports a growing network of nuclear and radiological security practitioners through best practice technical exchanges and through development of nuclear security Centers of Excellence (COEs) and other nuclear security support centers.

To complement efforts to secure materials at their source, GMS supports the recovery of orphaned or disused radioactive sources (both domestically and abroad) and their transportation to secure storage locations or for final disposition. GMS also offers training courses and resources, such as radiation detection equipment and online learning tools, to aid in the search and recovery of abandoned radioactive sources. GMS encourages permanent risk reduction by promoting the use of non-radioisotopic, alternative technologies to reduce, where possible, the number of radioactive sources in the civilian sector.

To address nuclear or radiological materials out of regulatory control, GMS strengthens the capacity and commitment of foreign governments to deter, detect, and investigate illicit trafficking in nuclear and radiological materials across international borders, both maritime and continental. GMS provides radiation detection systems, training, maintenance, and analytical support to partner countries, as part of the United States' global defense-in-depth approach to countering nuclear trafficking. These detection systems are the single largest component of the exterior layer of the Global Nuclear Detection Architecture, which is the U.S. Government framework for detecting, analyzing, and reporting on nuclear and other radioactive materials out of regulatory control. GMS also works to enhance partner countries' nuclear forensics capabilities to assist investigations and prosecutions.

In the long term, each partner country must be able to sustain its ability to secure, control, and interdict nuclear and radiological materials. The sustainability component of the GMS program strategy focuses on developing this indigenous capacity through a range of programs designed to ensure that countries can train, maintain, exercise, test, and improve the systems, personnel, and infrastructure that support nuclear and radiological security. Across all mission areas, GMS strives to build and maintain relationships with partner countries in order to facilitate a strong and enduring focus on nuclear and radiological security.

GMS uses the following principles to guide its prioritization and structuring of activities:

- **Reduce Imminent Risks:** The variety of external and insider threats to acquire vulnerable material, plus the numerous illicit trafficking pathways, requires adaptable programs that can disrupt current and emerging security risks. GMS considers political stability, terrorist activity, the presence of groups interested in acquiring nuclear/radiological materials, and prior incidents of trafficking in these materials (along with other factors) in developing a global prioritization.

- **Target–Out Approach:** The probability of interruption and neutralization of an attempted theft, as well as the probability of detecting an attempt to smuggle material, is highest when security measures are located closest to the source of the "target" materials.
- **Defense-in-Depth:** No facility or border security system is foolproof. All systems are limited by technical capabilities, human error, corruption, deterioration, and other factors. These weaknesses can be mitigated by establishing multiple layers of security and detection.
- **Graded Approach:** GMS's nuclear and radiological security elements consider the potential consequences posed by the theft or loss of a given material (i.e., a graded assessment of the destructive potential of the material and the ease with which it could be converted into a weapon). GMS also evaluates the effectiveness of the facility's security systems against potential threats (e.g., break-ins, insider threats, acts of sabotage). Similarly, GMS's nuclear detection effort considers a variety of possible smuggling vectors and pathways, and plans its deployments based on where the greatest risk reduction can be achieved.
- **Permanent Risk Reduction:** GMS encourages nuclear and radiological material consolidation in order to reduce vulnerability, and works with DOE/NNSA's research and development capabilities, national laboratories, and relevant U.S. Government agencies to promote non-radioisotopic alternative technologies as replacements for high-activity radioactive sources.
- **Attention to Cyber Risks:** GMS programs have begun to incorporate cybersecurity into their nuclear, radiological, and detection missions, including work with bilateral partners and the IAEA to develop guidelines and training on cybersecurity fundamentals. The overall aim is to promote the consideration of cyber threats and risks into vulnerability assessments and security plans.
- **Commitment to Sustainability:** In order for security improvements to be sustained, partner countries must commit resources to national regulations, oversight, system operation, and security culture. GMS programs work with partners to establish these elements and design projects to fit within the partner's ability to sustain and operate them over the long term.
- **Customization:** GMS customizes activities with partner countries to meet particular needs. For example, GMS deploys detection systems to match the environments in which they will be deployed. For example, radiation portal monitors work well at existing checkpoints, such as border crossings, airports, and seaports, which already have a security infrastructure in place. GMS also offers mobile detection tools that can be better suited for more challenging environments, such as along borders with mountains or rivers, in disputed territories, or in locations within country interiors where law enforcement operational capacity may be challenged.
- **Political Factors:** Political support from the host government or sites as well as the security situation on the ground in a country are the final determining factors for engagement. For international partners with especially unstable security environments, GMS has conducted trainings in third countries as an alternative.

GMS regularly assesses its planned activities in specific countries (physical protection upgrades, exchanges of nuclear and radiological best practices, and detection activities at border crossings, ports, and within countries) to ensure that these activities are consistent with the current threat environment and U.S. policy and reflect the best use of program resources.

GMS regularly reports its performance by measuring (a) the cumulative number of buildings containing nuclear and radiological material that have been protected (i.e., received security enhancements); (b) the cumulative number of sites with installed nuclear detection equipment and the cumulative number of mobile detection systems deployed; and (c) the cumulative number of fixed radiation detection sites and mobile detection system deployments that are being indigenously sustained. In addition, GMS analyzes and tracks the number of disused radioactive sources of U.S.-origin recovered in the United States, as well as from other countries, and the number of radioactive source-based devices replaced with safer alternatives in the United States. GMS tracks performance and effectiveness of radiation detection equipment based on data received from partner countries.

2.2.2 FY 2017 Activities, Accomplishments, and Challenges

GMS supports activities in three areas: International Nuclear Security, Radiological Security, and Nuclear Smuggling Detection and Deterrence.

International Nuclear Security

The **International Nuclear Security** program strengthens partner capacity to secure nuclear material and facilities through support for: nuclear security system enhancements; training, training centers, workshops, and technical exchanges; nuclear security infrastructure (regulations, inspections); nuclear security culture; mitigation of insider threats; and cybersecurity awareness.

FY 2017 Accomplishments

- Supported joint development and execution of nuclear security best practices exchanges and training courses with COEs in Argentina, China, India, Japan, and South Korea. These COEs address nuclear security training requirements within each country and provide a forum for bilateral and regional best practice exchanges.
- Funded ongoing curriculum development for the national nuclear security training center in Kazakhstan, which opened in May 2017.
- Supported nuclear security best practices exchanges and/or training courses with Belarus, Israel, Jordan, Vietnam, and other international partners.
- Continued to support physical protection upgrades at the South Ukraine Nuclear Power Plant and training for the Ukrainian National Guard, which is responsible for protecting Ukrainian nuclear facilities.
- Supported physical protection upgrades at the Metsamor Nuclear Power Plant in Armenia.

Program Challenges

- Managing risks associated with the increasing number of emerging nuclear power states.
- International partners placing greater emphasis on implementing nuclear safety measures, at the expense of nuclear security measures.
- Continued terrorist interest in acquiring nuclear materials and/or targeting nuclear facilities.
- Accelerated growth and increased dynamism of cyber threats.

China Opens Nuclear Security Center of Excellence

On March 18, 2016, the People's Republic of China commissioned its COE for nuclear security. Fulfilling a Chinese commitment from the 2010 Nuclear Security Summit, the COE will address China's domestic nuclear security training requirements, provide a forum for bilateral and regional best practice exchanges, and serve as a venue for demonstrating advanced technologies related to nuclear security. The **GMS International Nuclear Security Program** led a team of experts from **Sandia National Laboratories (SNL)** in Albuquerque, NM, **Los Alamos National Laboratory** in Los Alamos, NM, **Oak Ridge National Laboratory** in Oak Ridge, TN, and **Pacific Northwest National Laboratory** in Richland, WA that worked with the Chinese State Nuclear Security Technology Center (SNSTC) on the design, selection, and installation of equipment and training curriculum for the COE. In one example of this cooperation, the SNL team worked with their SNSTC colleagues on the design, operation, and testing of a physical protection system to be used in a mock material processing facility at the COE for training in the proper handling and storage of special nuclear material. The **DOD Cooperative Threat Reduction Program** also contributed equipment and expertise crucial to the design and development of the center. In the future, the U.S. and Chinese teams will continue their cooperative work in developing training courses and materials to support further development of Chinese and other regional nuclear security professionals who are protecting nuclear facilities and materials.

Secretary Perry visits the State Nuclear Security Technology Training Center, Beijing, China

Radiological Security

The **Office of Radiological Security (ORS)** works worldwide to protect, remove, and reduce the reliance on vulnerable high-priority radioactive sources that could be used in RDDs or radiological exposure devices.

ORS cooperates with domestic and international partners to enhance the security of high-activity sources, many of which are located at sites with low security environments (e.g., hospitals and research facilities). These enhancements include physical protection equipment, and training designed to augment timely response and to improve overall security system effectiveness toward preventing material theft. ORS is currently investing in longer-term sustainable security applications by collaborating with industry on security by design and in-device delay measures. Such measures will make devices using radioactive sources inherently more secure both in static storage and when field-deployed.

Figure 7. Removal of Radiological Device from Temple University in Philadelphia, PA

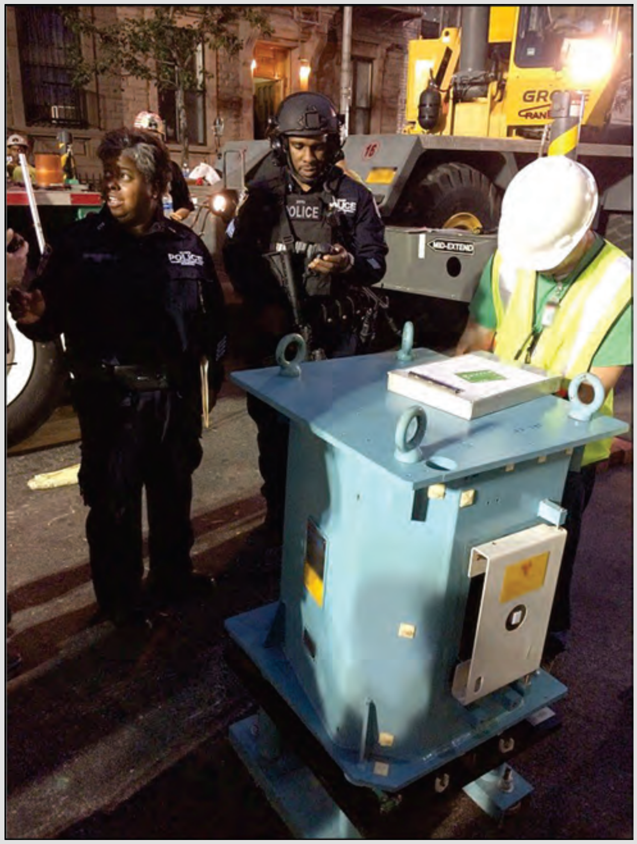
Considering the volume of high-priority sites globally, ORS works to reduce the global reliance on highly-radioactive sources by: (a) promoting the adoption and development of alternative technologies, (b) collaborating with partners through the promotion of information sharing and analytical studies, and (c) initiating and evaluating pilot replacement projects around the world.

ORS also works with partners and the IAEA to develop end-of-life management solutions for radioactive sources. Assistance in this area may include source consolidation and in-country disposition, support in removal efforts, and search and security training and equipment for abandoned or missing sources.

FY 2017 Accomplishments

- Completed upgrades at an additional 97 buildings with high-priority radioactive sources (49 domestic sites and 48 international sites), for a cumulative total of 2,196.
- Conducted 29 training workshops in the United States and abroad designed to enhance timely response and to improve overall security system effectiveness with the goal of preventing material theft.
- Increased training and engagement to develop a security culture at radiological sites domestically and internationally, while working with sites to understand and identify resources needed to maintain the long-term sustainability of physical security systems. Abroad, national-level sustainability continued to be a priority through assistance with the development of security regulations, training of regulatory staff, security awareness training courses, and engaging other national-level stakeholders who can assist with allocating resources for the sustainability of upgrades.
- Recovered an additional 2,119 unwanted radioactive sealed sources from sites located throughout the United States.

Recovering and Disposing Sealed Radioactive Sources



NYPD officers test the functionality of their radiation detection equipment as the radiation control technician takes measurements on the blood irradiation device prior to loading in the Type B container.

The Off-Site Source Recovery Program (OSRP), through funding from the **ORS**, recovers and disposes of disused sealed radioactive sources in the interest of national security and public health and safety. Since 1997, OSRP has removed over 37,000 radioactive sealed sources containing more than 1 million Curies of material from over 1,300 industrial, educational, healthcare, and government facilities worldwide. OSRP is a cooperative effort between **Los Alamos National Laboratory (LANL), Idaho National Laboratory (INL)**, in Idaho Falls, ID and **Lawrence Livermore National Laboratory (LLNL)**.

During FY 2016, OSRP recovered over 2,500 disused sealed radioactive sources. In one such recovery, OSRP removed a device used to irradiate blood from a hospital in downtown New York City. The device was removed from the hospital overnight and shipped in an NNSA-owned Type B cask. This required complex planning on the part of LANL and INL, as well as many state and city agencies to secure the necessary permits to transport the device through the city.

- Promoted long-term risk reduction both domestically and internationally through engagement on alternative technologies; and replaced 16 high-activity, radioactive source-based devices in the United States with devices that do not use radioactive sources.
- Established new partnerships, and expanded existing ones, with high-income countries through technical meetings and exchanges to share lessons learned, best practices, and experiences in the area of radiological security.

Program Challenges

- Sustaining commitment to radiological security and more nuanced understanding of the threat, both domestically and internationally.
- Reinforcing the importance of a timely and effective response to alarm incidents in order to prevent the theft of radiological material.
- Building international consensus on end-of-life management for radioactive sources, including repatriation, disposition, or long-term secure storage.
- Ensuring additional financial and technical support needed to promote alternative technologies for radioactive sources.
- Working in volatile security environments that can cause project delays and disruptions in many regions, especially Africa and the Middle East.
- Improving the insufficient or unclear regulatory authority and regulations on source security in many developing countries, which are necessary for a country's source security to be sustainable.

Nuclear Smuggling Detection and Deterrence

The **Office of Nuclear Smuggling Detection and Deterrence (NSDD)** strengthens the capacity and commitment of foreign governments to deter, detect, and investigate illicit trafficking in nuclear and other radioactive materials. NSDD's strategy is to improve partner countries' capacity by providing radiation detection systems and associated training, maintenance, and sustainability support. NSDD deploys its systems at carefully selected locations as part of the broader U.S. Government-led, global defense-in-depth approach to countering nuclear trafficking. NSDD also works with international partners to enhance their nuclear forensics capabilities. NSDD coordinates with the IAEA, the European Union, INTERPOL, law enforcement, and other organizations to facilitate coordination and consistency in efforts to counter nuclear smuggling worldwide.

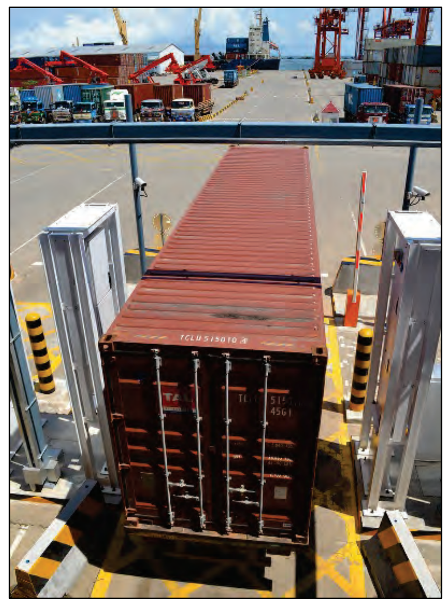


Figure 8. Radiation Scanning at a Seaport

FY 2017 Accomplishments

- Deployed 26 mobile radiation detection systems and provide fixed systems to 30 new sites to help counter the threat of illicit trafficking of nuclear and radiological materials; the bulk of these systems will be deployed in countries in Eastern Europe, the Middle East, and Africa.
- Deployed flexible radiation detection capabilities at one strategic airport in Southeast Europe. Also deployed flexible detection capabilities in two countries in the Indian Ocean and Black Sea regions to perform targeted screening of small maritime vessels.
- Transitioned 92 radiation detection systems to partner country responsibility.
- Expanded bilateral nuclear forensics partnerships and supported multilateral nuclear forensics efforts in 16 countries through workshops and other assistance activities on nuclear forensics.

- Built exercise programs in eight partner countries to teach these countries best practices in evaluating their own detection systems and forensics capabilities.

Program Challenges

- Effectively communicating the importance of both fixed and mobile detection technologies as critical elements of a multilayered approach to preventing nuclear smuggling.
- Finding ways for some partner countries to assume responsibility for deployed systems in spite of their internal resource constraints, political instability, or other factors that may impact transition timelines.

2.2.3 FY 2018 Future Years Program Plan

For FY 2018, GMS will continue to work with international partners to enhance nuclear and radiological security both bilaterally and through multilateral forums. Civil nuclear programs around the world will continue to expand, requiring a sustained focus on nuclear security best practices. Nuclear security COEs and other nuclear security support centers will be increasingly important to further nuclear security best practices and technical exchanges bilaterally and regionally.

GMS will continue to make priority upgrades to security at radiological sites in the United States and abroad, while striving to move disused sources to secure disposition sites. Where feasible, GMS will partner with sites that volunteer to replace high-activity radiological devices with non-isotopic technologies, thus creating permanent threat reduction and eliminating the need for sustainment of security upgrades. GMS will continue to enhance and sustain partner country capabilities to detect and investigate illicit trafficking. GMS will expand flexible detection initiatives at strategic airports and for targeted screening of small maritime vessels and support the expansion of nuclear forensics capabilities.

Main Areas of Program Activity for FY 2018

- Support training courses at partner country nuclear security training centers, conduct technical exchanges and workshops with international partners, and provide technical support on nuclear and radiological security topics, including cybersecurity and nuclear detection.
- Continue ongoing capacity building cooperation to support implementation of physical protection recommendations in IAEA Information Circular (INFCIRC) 225/Rev 5 and the IAEA Nuclear Material Accounting and Control guidelines document.
- Continue to support the IAEA to further nuclear and radiological security initiatives, including: developing Nuclear Security Series documents; supporting International Physical Protection Advisory Service missions; strengthening nuclear facility best practices, including cybersecurity best practices; and improving nuclear forensics capabilities worldwide.
- Continue providing limited sustainability support, in select cases, to foreign partner’s nuclear sites with nuclear security equipment upgrades, including support for training, procedures, maintenance, equipment repair, critical spare parts, and performance testing.
- Complete security upgrades at 90 additional buildings that contain high-priority radiological material, including 45 buildings in the United States and 45 buildings in other high-priority countries.
- Remove an additional 1,600 excess and unwanted sealed sources from locations throughout the United States.

- Perform targeted recovery and disposal of (or securely store) disused or orphaned radioactive sources in other countries.
- Replace 15 devices, which use high-activity radioactive sources, with those that use alternative non-radioisotopic technologies; and expand education and outreach to encourage a broader adoption of alternative non-radioisotopic technologies.
- Expand efforts to more efficiently and effectively address out-year scope and find better long-term threat reduction solutions, including deployment of source tracking tools and further development and application of new technologies that do not rely on radioactive sources.
- Provide 20 additional mobile and man-portable systems for use by law enforcement at internal checkpoints in countries along known smuggling routes and equip 16 official crossing points to close key gaps in the global nuclear detection architecture.
- Transition 64 radiation detection systems to indigenous sustainment.
- Provide flexible radiation detection capabilities for targeted screening of small maritime vessels and at high-priority airports in the Middle East, Eastern Europe, Africa, and Asia.
- Conduct approximately 40 events, workshops, or exercises to advance partner country capabilities in radiation detection, equipment maintenance, and forensics.

Approaches to Address Program Challenges

- GMS will continue to work to ensure partner countries have the commitment and capacity to address nuclear/radiological security and smuggling threats.
- To promote site and national level sustainability, GMS will continue to support development of indigenous regulatory, financial planning, and training frameworks and strive to meet international partners' particular requirements.
- GMS will also continue to leverage the work of international organizations (such as the IAEA) to foster effective global nuclear security norms and help maintain security enhancements over the long term.

2.3 Nonproliferation and Arms Control

2.3.1 Program Strategy, Priorities, and Performance Metrics

NPAC works to prevent proliferation of sensitive nuclear and dual-use technology, equipment, and information; ensure peaceful nuclear uses; and enable verifiable nuclear arms reduction.

The DNN Office of Nonproliferation and Arms Control (NPAC) strengthens the nonproliferation and arms control regimes by working to: (1) detect and deter undeclared nuclear materials and activities, and diversion of declared material; (2) detect and deter illicit transfers of nuclear and dual-use materials, equipment, and technology; (3) enable verified nuclear weapons reductions; and (4) address evolving threats, challenges, and compliance concerns associated with the nonproliferation and arms control regimes. NPAC implements a comprehensive and integrated set of initiatives and activities to achieve these four key objectives that are designed to: (1) build capacity of the IAEA and its Member States to implement and meet safeguards obligations; (2) build domestic and international capacity to implement export controls; (3) develop and implement verification regimes for nuclear weapon reductions, and to detect and dismantle undeclared nuclear programs; and (4) develop programs and strategies to address emerging nonproliferation and arms control challenges and opportunities. NPAC advances the long-term sustainability of its programs through train-the-trainer capacity-building approaches, partnerships with international organizations to incorporate nonproliferation best practices among IAEA Member States, and applied technology development tailored to address an identified nuclear safeguards or verification deficiency. Accordingly, NPAC metrics are designed to gauge progress toward self-sustaining and measurable outcomes.

Figure 9. Nuclear Safeguards Training in the Lao People's Democratic Republic

The NPAC program prioritizes its work according to the following categories:

- **Statutory Mandates/Authorities:** Activities that DOE is legally required or authorized to implement, such as implementation of U.S. safeguards obligations under the Voluntary Offer Agreement/Additional Protocol; technical reviews of domestic export licenses and Code of Federal Regulations (CFR) Title 10 Part 810 applications for nuclear technology exports; and technical support for the negotiation of peaceful nuclear cooperation agreements (i.e., Atomic Energy Act Section 123 Agreements).
- **Treaties and Other International Agreements:** Activities that implement legally-binding treaty and other international agreement obligations, such as supporting implementation of the New Strategic Arms Reduction Treaty (New START), the U.S.-Russian Federation Plutonium Production Reactor Agreement (PPRA), the Biological Weapons and Toxins Convention, and the Chemical Weapons Convention (CWC).
- **Presidential Priorities:** Activities to accomplish Administration priorities/objectives articulated in national-level policy guidance (e.g., Next Generation Safeguards Initiative (NGSI), maintaining readiness for denuclearization activities, and select export control foreign capacity building).
- **Non-binding Engagements with International Partners:** Activities that implement international engagements in the form of memoranda of understanding and cooperation/statements of intent (e.g., select export control foreign capacity building and Track 1.5 engagements).

Building on these overall categories, as applicable, NPAC subprograms also use risk prioritization methodologies to determine specific outreach priorities and annual resource allocations. These methodologies include quantitative rankings of objective risk criteria that are then weighted to reflect their relative importance to the respective program missions. For example, NPAC's Physical Protection Assessments subprogram, which works to ensure the security of U.S. nuclear material exported to foreign countries for peaceful purposes, uses a prioritization methodology to determine the annual schedule for visits to foreign partner facilities. The methodology considers several factors such as material type and quantity, known physical protection inadequacies (or lack of information on physical protection adequacies), projected exports of nuclear material to the country/facility, and the history of prior assessments. As part of this process, NPAC subprograms also overlay U.S. Government policies and priorities and account for related activities in other DOE/NNSA programs and U.S. Government agencies to ensure appropriate coordination and leveraging of resources.

To assess progress toward its program objectives, the NPAC program regularly evaluates its performance by measuring: (a) the annual number of safeguards tools deployed and used in international regimes and other countries that address an identified safeguards deficiency; (b) the cumulative number of countries where NPAC is engaged that have export control systems that meet critical requirements; and (c) the physical security of U.S.-obligated nuclear material located at foreign facilities, determined by conducting bilateral physical security assessment reviews. In addition, NPAC applies qualitative measures to evaluate its ability to effectively respond to administration priorities and evolving international opportunities and challenges.

2.3.2 FY 2017 Activities, Accomplishments, and Challenges

The NPAC Program supports activities in four areas: Nuclear Safeguards, Nuclear Export Controls, Nuclear Verification, and Nonproliferation Policy.

Nuclear Safeguards

Nuclear Safeguards strengthens the international safeguards regime and the IAEA's ability to detect non-compliance through the implementation of NGSI. NPAC launched NGSI in 2008 to develop the policies, concepts and approaches, human capital, technology, and infrastructure required to strengthen the international safeguards system and provide the IAEA with the necessary resources to meet its evolving mission. NPAC's International Nuclear Safeguards Office has the following three areas of concentration: Safeguards Policy, Concepts and Approaches, and Human Capital Development; International Safeguards Engagement; and Safeguards Technology Development. In addition, the International Nuclear Safeguards Office contributes to several other related mission areas. It is the lead program within DOE for overseeing U.S. safeguards obligations under the U.S. Voluntary Offer Agreement and the U.S. Additional Protocol. It is also responsible for executing the Department's statutory mandate under the *Atomic Energy Act of 1954*, as amended, and Nuclear Regulatory Commission (NRC) Regulations (10 CFR 110.44) to ensure the security of U.S. nuclear material exported to foreign countries for peaceful purposes.

Figure 10. Vietnamese Regulatory Officials Conducting Nuclear Safeguards Exercise

FY 2017 Accomplishments

- Maintained qualified and knowledgeable safeguards staff at the national laboratories and the IAEA in support of the international safeguards regime by providing sustainable academic and technical programs, internships, post-graduate and graduate fellowships, and short courses on safeguards.

- Provided safeguards expert support to the U.S. Government and the IAEA for the implementation of the IAEA's state-level approach, with a focus on improving analytical measures of state-specific factors on nuclear fuel cycle capabilities.
- Field tested and finalized advanced safeguards concepts to track uranium hexafluoride cylinders throughout their lifecycle and strengthen the IAEA's matching of nuclear material shipments and receipts.
- Supported IAEA in developing tools and approaches for the Agency's expanded monitoring mission in Iran under the JCPOA.
- Implemented U.S.-IAEA safeguards obligations at DOE facilities (including annual reporting requirements).
- Continued to build nuclear safeguards capacity by providing customized training to more than 30 countries to develop effective State Systems of Accounting and Control and strengthen implementation of Comprehensive Safeguards Agreements and Additional Protocols.
- Partnered with the IAEA and advanced nuclear partners to conduct joint nuclear safeguards outreach to existing partners and additional "nuclear newcomer" states.
- Developed a tool to strengthen the IAEA's ability to assess different combinations of declared and undeclared steps along the nuclear fuel cycle for obtaining weapons-usable material to optimize inspections.
- Completed field trials of an unattended monitoring system for detecting undeclared enrichment of uranium.
- Transferred to the IAEA a versatile electronic module that can securely duplicate and transmit information from an existing measurement system to a safeguards inspectorate's system to enhance inspector capabilities for unattended, in-field detection of undeclared activities.
- Completed six bilateral physical security assessment reviews of foreign sites that possess, or are requesting to receive, U.S.-obligated nuclear material.

Program Challenges

- Growing number of nuclear facilities and increasing amount of nuclear materials under IAEA safeguards are outpacing the IAEA's resources in an era of a flat (or zero-growth) budget.
- Potential resource demands that could be imposed by sudden, transformative events.
- Partner countries have limited capability to incorporate additional resources, funding, and staff continuity.
- Difficulty attracting and retaining mid-career experts in the safeguards field.
- Gaining access to facilities to conduct bilateral physical protection assessment visits is contingent on host government agreement and cooperation to support such visits.

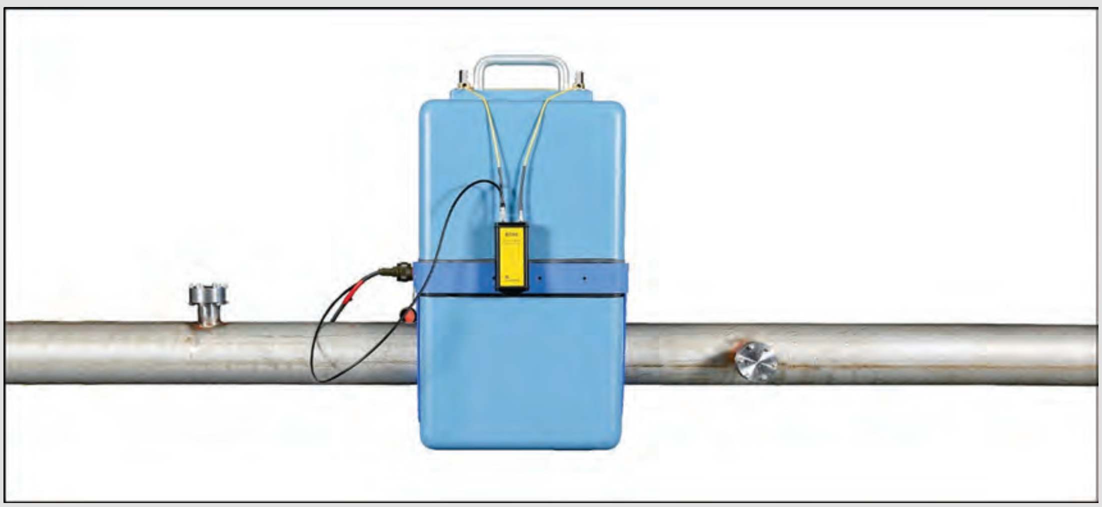
Strengthening Global Nuclear Safeguards with Advanced Technology

Safeguards enable the IAEA to provide credible assurances that nuclear material is only used for peaceful purposes. As part of its nonproliferation mission, DOE/NNSA develops technological capabilities that help strengthen the IAEA nuclear safeguards mission. For example, **Oak Ridge National Laboratory** and **Los Alamos National Laboratory**, with support from by **Pacific Northwest National Laboratory,** developed the On-Line Enrichment Monitor (OLEM) and transferred it to the IAEA, which will use it to verify compliance with safeguards agreements.

OLEM allows inspectors to measure the enrichment level of uranium as it flows through a gas centrifuge enrichment plant. To determine the level of enrichment, OLEM must measure the concentration of U-235 atoms passing through a pipe in a fixed period of time. These types of data are collected and analyzed by a small computer contained inside OLEM. The data are processed continuously by computer algorithms, making minimal human interface is necessary to extract results. These analyses are transmitted through an encrypted network to a remote computer, where an IAEA inspector can retrieve and evaluate them.

OLEM is a unique safeguards technology because it provides real-time measurements while material is moving through an industrial process, rather than the previously available sampling techniques, which could take up to three weeks to yield results. Not only are the results available in real-time, allowing inspectors to monitor safeguards more effectively, but OLEM also enables the IAEA to implement safeguards agreements in a more cost-efficient way.

On-line enrichment monitoring was used to monitor HEU down-blending operations in Russia, as part of the 1992 U.S.-Russia HEU Purchase Agreement. Today, pursuant to the JCPOA, the IAEA is using the OLEM to monitor the Iranian gas centrifuge enrichment plant at Natanz.



An OLEM collection node attached to a gas centrifuge enrichment plant's header pipe.

Nuclear Export Controls

Nuclear Export Controls facilitates nuclear cooperation by building global capacity to prevent the spread of nuclear and dual-use materials, equipment, and technology. NPAC's Nuclear Export Controls Office accomplishes this mission through the following three subprogram areas: Export Control Review, Compliance Guidance, and Enforcement support; U.S. WMD Interdiction efforts; and the International Nonproliferation and Export Control Program. The Nuclear Export Controls Office (1) conducts technical reviews of domestic export licenses for dual-use commodities (thousands each year) and provides guidance to help strengthen export control compliance across the DOE complex; (2) provides technical support to enhance U.S. Government capacity to detect and interdict illicit WMD-related commodity technology transfers to foreign programs of concern and conducts all-source, technical assessments to address the gaps in export control regulations; (3) strengthens foreign partner national systems of export control in coordination with (and with some funding support from) other U.S. interagency partners (such as the DOS Export Control and Related Border Security program), consistent with U.S. policy and the multilateral supplier regimes; and (4) provides training and technical support for U.S. enforcement agencies.

FY 2017 Accomplishments

- Bolstered the U.S. Government's ability to prevent and interdict U.S.-origin transfers that would contribute to foreign WMD programs of concern through export review and compliance guidance.
- Performed statutorily mandated technical reviews of thousands of U.S. dual-use export license applications within the 30-day deadline.
- Provided timely guidance to the DOE national laboratory complex and other contractors to promote compliance with export-control requirements.
- Provided technical inputs to U.S. Government reviews of WMD interdiction and sanctions cases.
- Anticipated and addressed proliferation risks posed by emerging dual-use technologies.
- Continued efforts to maintain and enhance key information technology systems supporting NPAC export licensing and interdiction missions, as well as the multilateral export control regime missions (Nuclear Suppliers Group [NSG] and Australia Group).
- Supported training events for U.S. inspectors and investigators to protect the U.S. industrial base from potential exploitation by proliferators.
- Supported DHS's Homeland Security Investigations training events for foreign partners with a tailored WMD commodity identification curriculum for investigators.
- Continued technical support to the World Customs Organization's Strategic Trade Control Enforcement training program and ensured that NPAC laboratory instructors received training on the World Customs Organization's enforcement curriculum.
- Worked as part of the interagency team to develop and implement the technical end user review process for third countries' proposed exports to Iran of nuclear and dual-use items, as required by the JCPOA and the United Nations' Security Council.

Program Challenges

- Some international partners have limited capacity to engage in bilateral and regional export control cooperative arrangements, which may curtail the extent of cooperation possible in a given fiscal year.

Nuclear Verification

Nuclear Verification reduces and eliminates proliferation concerns by supporting the development, negotiation, and implementation of U.S. nonproliferation and arms control treaties and other international agreements. NPAC's Office of Nuclear Verification conducts applied technology development, testing, evaluation, and deployment of proven technical concepts to ensure the availability and application of required verification capabilities and to lay the foundation for future nonproliferation initiatives by developing solutions to best accomplish U.S. objectives while balancing safety, security, and operational considerations. Nuclear Verification is organized into the following subprograms: Warhead Dismantlement and Fissile Material Transparency, and Nuclear Noncompliance Verification.

FY 2017 Accomplishments

- Provided continued arms control implementation support, including through the New START Treaty Bilateral Consultative Commission; and the U.S. Backstopping Committee and Verification and Compliance Analysis Working Groups for the New START Treaty, the Intermediate-Range Nuclear Forces (INF) Treaty, and the Treaty on Open Skies.
- Completed annual monitoring visits in Russia under the terms of the U.S.-Russia PPRA to ensure the non-weapons use of Russian plutonium oxide and non-operational status of shutdown Russian plutonium production reactors. Hosted Russian monitors at U.S. facilities falling under the PPRA. Brought two of the last three shutdown Russian reactors under PPRA monitoring following the FY 2016 Joint Expert Familiarization Visit (JEV) at Seversk, and prepared for the JEV at Zheleznogorsk.
- Maintained the capability to exert U.S. verification rights under the Limited Nuclear-Test-Ban Treaty (LTBT), the Threshold Nuclear-Test-Ban Treaty (TTBT), and the Peaceful Nuclear Explosions Treaty.
- Worked with the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO Prepcom) to strengthen operation of the International Monitoring System (IMS), supported by the International Data Centre (IDC), and planned for a Comprehensive Nuclear-Test-Ban Treaty (CTBT) on-site inspection (OSI) training activity at the Nevada National Security Site (NNSS) in early FY 2018. Managed DOE/NNSA participation in the CTBT Science and Technology 2017 Conference.
- Developed and assessed advanced technologies and concepts for future warhead and fissile material transparency and verification regimes that protect U.S. national security interests while enabling U.S. policy objectives.
- Developed, tested, and evaluated verification procedures and technologies to monitor, verify, and dismantle uranium and plutonium weapons activities in countries of concern.
- Continued to provide operations planning and training and maintain readiness of U.S. verification teams, technologies, and capabilities to support the verifiable dismantlement of nuclear programs in countries of proliferation concern.
- Continued to maintain the Organization for the Prohibition of Chemical Weapons (OPCW) Designated Laboratory at Lawrence Livermore National Laboratory to U.S. support implementation of the CWC. Successfully completed both environmental and biomedical sample proficiency testing.

Program Challenges

- Russia’s ongoing violation of the INF Treaty and the potential implications.
- Countries of concern unwilling to uphold previous nonproliferation agreements and unwilling to negotiate new agreements.

Figure 11. Signing of the Administrative Arrangement Implementing the U.S. – Republic of Korea Civil Nuclear Cooperation Agreement

Nonproliferation Policy

Nonproliferation Policy provides programs and strategies to reduce nuclear dangers; address emerging challenges and opportunities in nonproliferation and arms control; and support the implementation of bilateral, multilateral, Presidentially-directed, or congressionally-mandated nonproliferation and international security initiatives, agreements, and treaties. These capabilities support NPAC's core competency areas which are charged with implementation (international nuclear safeguards, nuclear export controls, and nuclear verification). This overarching and crosscutting policy function also informs DNN, NNSA, DOE, and supports the U.S. interagency and U.S. participation in multilateral organizations.

FY 2017 Accomplishments

- Achieved entry into force for a new civil nuclear cooperation agreement (123 Agreement) with Norway. Concluded negotiations and achieved entry into force for a new 123 Agreement with Mexico.
- Supported U.S. participation in the 2017 NPT Preparatory Committee, the first of three Preparatory Committees in the NPT 2020 Review Conference cycle.
- Modernized the 10 CFR Part 810 process governing unclassified nuclear technology and assistance exports by implementing the Part 810 process improvement plan and e810 online authorization system.
- Developed and implemented innovative Track 1.5 engagement activities in South Asia, Southeast Asia, and the Middle East, as well as unique social media activities in South Asia, to address emerging challenges and opportunities in nonproliferation and arms control.

Program Challenges

- Managing the balance between the nonproliferation objectives of Part 810 and the benefits of U.S. commercial participation in foreign civil nuclear power programs.

- Continuing strains on the NPT as the cornerstone of the international nonproliferation regime and the growing need to support progress across the three pillars of the treaty: disarmament, nonproliferation, and the peaceful uses of nuclear energy.
- Managing external challenges to the nonproliferation regime, including global change, technological advancement, political unpredictability, and countries of concern actively pursuing WMD.
- Tensions between India and Pakistan, which challenge the USG to create an appropriate nonproliferation policy approach.

2.3.3 FY 2018 Future Years Program Plan

For FY 2018, NPAC will place increasing emphasis on strengthening the U.S. safeguards technology and human capital base to meet projected U.S. and IAEA resource requirements. NPAC also will continue to support implementation of the JCPOA to address Iran's nuclear program through safeguards and export control activities. Further, NPAC will provide for export control-related activities that address proliferation by North Korea, Syria, and proliferation networks as well as risks posed by emerging technologies; strengthening international nonproliferation agreements and standards; and encouraging global adherence to and implementation of international nonproliferation requirements. Finally, in collaboration with the DNN Office of Research and Development (DNN R&D), NPAC will support the development and evaluation of negotiating positions and verification technologies to support U.S. arms control and nonproliferation initiatives. This includes applied development, testing and evaluation, and deployment of advanced radiation measurement technologies, as well as other concept-proven technologies for treaty verification, transparency, and safeguards purposes.

Main Areas of Program Activity for FY 2018

- Meet standing DOE/NNSA statutory and treaty/agreement obligations and authorities, including: (a) leading 6–8 physical security assessment visits for U.S.-obligated materials at foreign facilities; (b) implementing U.S.-IAEA safeguards obligations at DOE facilities under the U.S. Voluntary Offer Agreement/Additional Protocol; (c) conducting U.S. nonproliferation and export control activities (license application and interdiction case technical reviews, 123 Agreements, 10 CFR Part 810 authorizations); (d) safeguards training; and (e) implementing DOE obligations under the New START Treaty, PPRA, CWC, and the Biological and Toxin Weapons Convention.
- Provide technical expertise and technology assistance to the IAEA to monitor compliance with the JCPOA through safeguards and export control activities. Also provide technical review of proposed transfers of items, materials, goods, and technology to Iran under the Procurement Working Group of the JCPOA and develop an information technology tracking system for all such requests.
- Strengthen the U.S. safeguards technology and human capital base to meet projected U.S. and IAEA resource requirements.
- Develop safeguards, concepts, and approaches for new facilities and fuel cycles; promote safeguards by design directly with designers and industry; analyze the implications of emerging technology to international safeguards applications.
- Establish a safeguards experimental laboratory at a U.S. nuclear facility to serve as a safeguards training and education center for U.S. Government staff and graduate students and a proving ground for nascent safeguards technologies and concepts.

- Continue field testing advanced safeguards approaches for Gas Centrifuge Enrichment Plants, for eventual transfer to IAEA.
- Transfer five safeguards tools to foreign partners or international organization to meet identified safeguards deficiencies.
- Maintain support for accredited IAEA Network of Analytical Laboratories at DOE national laboratories.
- In partnership with the DOS's Export Control and Related Border Security program, engage 25–35 foreign partners to strengthen national systems of export control and prevent illicit trafficking in nuclear and dual-use commodities through export licensing and enforcement training programs, and advancing sustainability through train-the-trainer approaches.
- Work with other DOE and interagency partners to facilitate the expansion of civil nuclear power while minimizing proliferation risks through global outreach and capacity building in nuclear safeguards and export controls.
- Provide nonproliferation assessments of emerging technologies.
- Perform approximately 6,000 technical reviews of U.S. export licenses for nuclear and dual-use commodities, provide state-of-the-art technology assessments to the multilateral control regimes, and provide training courses for DOE and U.S. Government officials regarding changing export controlled technologies and proliferation concerns.
- Support the U.S. Government enforcement community by providing approximately 3,000 real-time technical analyses for interdiction cases per year, and provide unique analytical products regarding proliferation trends and commodity gaps through the Interdiction Technical Analysis Group.
- Provide support to DOE/NNSA programs for internal compliance with U.S. export control regulations.
- Develop advanced technical capabilities for warhead and fissile material monitoring and verification regimes, including for implementation of the New START Treaty, and prepare DOE and NNSA sites for the implementation of such initiatives.
- Conduct three monitoring visits in Russia under the terms of the PPRA to ensure the non-weapons use of Russian plutonium oxide and non-operational status of shutdown Russian plutonium production reactors and host Russian monitors on their annual monitoring visit to U.S. facilities falling under the PPRA.
- Maintain the capability to exert U.S. verification rights under the LTBT, the TTBT, and the Peaceful Nuclear Explosions Treaty.
- Continue activities related to nuclear testing limitations, including those that complement and may strengthen U.S. nuclear explosion monitoring and verification capabilities such as working with the CTBTO Prepcom to support operation and improvement of the IMS and the IDC, as well as hosting a CTBT OSI training activity at the NNSS.
- Develop, test, and evaluate verification procedures and technologies to monitor, verify, and dismantle uranium and plutonium weapons activities in countries of concern.
- Continue to provide operations planning and training to maintain readiness of U.S. verification teams, technologies, and capabilities to support the verifiable dismantlement of nuclear programs in countries of proliferation concern.

- Continue to maintain the OPCW Designated Laboratory at Lawrence Livermore National Laboratory to support implementation of the CWC. Successfully complete both environmental and biomedical sample proficiency testing.
- Provide technical assistance to the negotiation of up to three Section 123 Agreements for Cooperation and their administrative arrangements.
- Continue to work with the NSG to strengthen controls on nuclear technology transfers, including amending the NSG Guidelines and ensuring the NSG control lists remain up to date with advancing technologies.
- Process 40–50 Part 810 specific authorization applications and requests for amendments per year and review over 100 Part 810 general authorization reports for compliance with Part 810 regulations per year.
- Conduct Track 1.5 engagements with India, Pakistan, Saudi Arabia, Egypt, Turkey, Burma, and China and leverage these efforts to build U.S. engagement and influence in nonproliferation and regional stability.
- Grow South Asia-focused social media and web presence to promote U.S. nonproliferation priorities in the region.

Approaches to Address Program Challenges

- Build capacity of the IAEA and Member States to implement and meet international safeguards obligations.
- Build domestic and international capacity to implement export control obligations.
- Support negotiation of and implement agreements and associated monitoring regimes to verifiably reduce nuclear weapons and dismantle undeclared nuclear programs.
- Develop programs and strategies to address emerging nonproliferation and arms control challenges and opportunities.
- Assess capacity of international partners to engage and prioritize level of annual engagement accordingly, giving higher priority to partners with greater capacity to engage cooperatively.
- Support U.S. Government initiatives to resolve Russia's ongoing violation of the INF Treaty through the application of verification experience, and policy and technical expertise.
- Maintain current knowledge about the existing nuclear fuel cycle infrastructure in countries of concern, and using this knowledge, develop and maintain the U.S. capabilities required to verify the dismantlement of illicit nuclear programs, maintaining short-notice readiness to deploy when called upon.
- Provide verification expertise to U.S. interagency policy discussions and preparations for future nonproliferation agreements.

2.4 Defense Nuclear Nonproliferation Research & Development

2.4.1 Program Strategy, Priorities, and Performance Metrics

DNN R&D seeks to develop and produce advanced technologies for detection of foreign weapons development, nuclear detonations, and movement/diversion of special nuclear materials.

The Office of Defense Nuclear Nonproliferation Research and Development (DNN R&D) reduces the threat to national security by advancing U.S. capabilities to detect and monitor foreign nuclear fuel cycle and weapons development activities, special nuclear material (SNM) movement or diversion, and nuclear explosions. These same capabilities support nuclear arms control treaty monitoring and verification, operational interdiction, and other nuclear security efforts across DOE/NNSA and the U.S. Government. This includes delivering space-based sensors to meet the nation's operational nuclear test treaty monitoring and integrated threat warning/attack assessment requirements. Finally, it includes improving the speed, accuracy, confidence, and specificity of nuclear forensics analytic capabilities.

To meet these DOE/NNSA mission needs, DNN R&D works with partner DOE national laboratories, sites, and plants, in addition to stakeholders and end-users, to make long-term strategic nuclear nonproliferation investment decisions. DNN R&D provides federal government oversight, direction, and implementation of these strategic investment decisions. Additionally, DNN R&D collaborates and invests with academia and private industry. Through these multiple partnerships and collaborations, DNN R&D advances the technical base for national and homeland security agencies to meet their nonproliferation, counterproliferation, incident response, and counterterrorism responsibilities.

Figure 12. Preparing for Source Physics Experiment, (Nevada National Security Site, NV)

DNN R&D aligns and prioritizes investment decisions through a transparent and collaborative research and development research cycle, supported by a structured project management and program review process that includes several opportunities for stakeholder input. There are many drivers that influence research and development funding priorities, including:

- U.S. strategic goals, as found in national-level documents, such as the *National Security Strategy* and the *Nuclear Posture Review*.

- Executive policy guidance, such as Presidential Policy Directive (PPD)-33 and PPD-42, plus other guidance from the National Security Council and Office of Science and Technology Policy.
- Statutory and treaty obligations.
- Congressional direction.
- National-level assessments of an investment's potential military or policy significance.
- DOE and NNSA strategic planning and policy guidance.
- Stakeholder requirements documents and inputs, such as from DOD, DOS, FBI, DHS, and the U.S. Intelligence Community.
- Stakeholder feedback from international partners.
- Assessments of technical state -of-the-art and advances in scientific understanding.
- Other government commitments to formal requirements, such as to the U.S. Nuclear Detonation Detection System.

The DNN R&D program has a specialized role within the national security and nonproliferation research and development community. The program conducts long-term nuclear nonproliferation research and development for DOE/NNSA and advances capabilities at the DOE national laboratories, which in turn enables mission stakeholders external to DOE/NNSA to leverage these capabilities for their own specific applications. The national laboratories are a national asset, providing broad spectrum support to U.S. strategic goals across multiple federal government components.

DNN R&D usually executes well in advance of formal requirements and often helps define future requirements for policy makers, negotiations, operational stakeholders, and technical systems by driving the art-of-the-possible and demonstrating prototypical technologies. Effective stakeholder coordination is paramount to ensuring proper alignment and phasing of the research and development investment strategies and operational end-users' acquisition strategies. Other federal agencies leverage DNN R&D investments through Strategic Partnership Project agreements with the DOE national laboratories.

Program-level performance is measured against progress defined in technology roadmaps corresponding to DNN R&D mission areas in Nuclear Weapons Development and Material Production Detection, Nuclear Weapons and Material Security, and Nuclear Detonation Detection. These multi-year roadmaps (typically five years in length) are developed by teams of subject matter experts, aligned to DOE and NNSA strategic goals and milestones, and vetted with the U.S. interagency community. Subject matter expert opinion establishes planned annual progress in each mission area. DNN R&D has a documented general framework for understanding research and development deliverables relative to technology maturation, and outlines an approach to technology readiness based on DOE and DOD terminology and definitions of technology readiness levels (TRLs). TRLs support the DNN R&D office in managing the process of developing technology solutions through maturation phases of:

- Proof of concept,
- Technology development and demonstration,
- Integration assessment and validation,
- Limited production and fielding, and
- Full implementation and operations.

Each funded project begins with a baseline TRL (state of the art) and an anticipated end-state TRL when the project is complete. Annual assessment of each project in the DNN R&D portfolio for TRL allows the tracking of progress in the overall mission areas as a percentage of effort along the full roadmap.

DNN R&D also builds and delivers to the U.S. Air Force the nation's operational sensors to monitor the entire planet from space in order to detect and report surface, atmospheric, or space nuclear detonations (NuDets). For over 50 years, the participating laboratories have demonstrated their unique and comprehensive understanding of nuclear weapons, the observables associated with nuclear detonations, and the propagation of signals to sensors. Moreover, these laboratories have extensive capabilities in the

Continued Research and Development on Detecting Nuclear Explosions from Space

In support of the United States Nuclear detonation Detection System (USNDS), **Sandia National Laboratories (SNL)** and **Los Alamos National Laboratory (LANL)** develop a payload suite of sensors called the Global Burst Detector (GBD), which is carried aboard every Global Positioning System (GPS) satellite. The GBD consists of subsystems developed by SNL and LANL, and SNL conducts the system engineering and integration of the payload and delivery to the U.S. Air Force's satellite contractor for hosting on the GPS satellite. A next-generation GBD system (which is proceeding through the critical system design review process) will combine capabilities to allow multiple phenomenology detection within a payload. This new GBD system is baselined against the constellation of GPS satellites scheduled for launch starting in the 2023 timeframe. The system includes an SNL-designed advanced sensor with a highly-pixelated focal plane that monitors the electro-optical spectrum for indications of a nuclear detonation. The sensor focal plane array design is based on almost a decade of SNL Laboratory Directed Research and Development investment.

Researcher Rachel Trojahn prepares one of the boxes that makes up SNL's GBD for a test in the Labs' Flight Test Chamber. The chamber exposes individual boxes and the fully assembled flight system to the vacuum and thermal environment they will experience in orbit. *(Photo: Randy Montoya)* design, construction, calibration, deployment, and operation of satellite-based instruments, along with detailed modeling and analysis methods to support continuous global monitoring.

DNN R&D supports three university-national laboratory consortia to develop the next generation of nuclear science and engineering expertise. These three consortia comprise the DOE/NNSA portion of the congressionally-directed Integrated University Program (IUP) established in the 2009 Omnibus Appropriations Bill. The IUP is in partnership with the NRC and DOE's Office of Nuclear Energy.

As a research and development organization, DNN R&D also participates in the Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) programs. DOE's Office of Science administers all SBIR/STTR across the Department.

2.4.2 FY 2017 Activities, Accomplishments, and Challenges

Nuclear Proliferation Detection

The **Office of Proliferation Detection (PD)** is a mission-focused, applied research and development subprogram within the DNN R&D program. PD sponsors research and development, principally at the DOE national laboratories, to develop advanced technical capabilities in support of U.S. national nuclear security and nonproliferation goals. PD efforts are aligned along three thrust areas.

The first thrust area for the PD programs is to advance U.S. technical capabilities to detect, characterize, and monitor the foreign production of SNM. Research objectives in this area focus on enriched uranium production detection, weapon-grade plutonium production detection, and the development of international safeguards technologies to monitor the peaceful use of SNM.

The second PD thrust area advances U.S. technical capabilities to detect, characterize, and monitor the foreign development of nuclear weapons. Research objectives in this area focus on nuclear weaponization detection efforts. Additionally, research investments support nuclear counterterrorism and nuclear incident response needs, including interdiction. To support potential nuclear arms control objectives, the research helps develop warhead verification and monitoring technologies.

The final PD thrust area advances enabling technologies for multi-use applications across the DOE/NNSA and interagency community, including advanced materials for radiation detection, novel approaches to both near-field and remote sensing, and leveraging advances in data science and signature physics. This thrust area also includes the IUP consortia of universities and DOE national laboratories that address basic research challenges in nuclear nonproliferation and security applications. Finally, this thrust area includes developing national test beds and performing associated experiments and research to demonstrate, validate, and confirm capabilities of significant interest to our mission stakeholders.

FY 2017 Accomplishments

- Developed and validated next generation sensor technologies and models to support SNM production and weapons development monitoring.
- Conducted a classified proliferation detection field campaign at Nevada National Security Site, including 19 campaign teams and approximately 125 personnel from across the interagency.
- Finalized a joint analysis effort with UK's National Nuclear Laboratory regarding Magnox fuel from the Calder Reactor Unit 1 that will dramatically improve the validation of high-fidelity reactor simulations in support of key nonproliferation objectives.
- Conducted a High Explosive (HE) campaign at Nevada National Security Site's Big Explosive Experimental Facility, improving confidence in capabilities to discern the sophistication of tested

devices, the maturity of a country's nuclear weapons program, and possibly the intent behind the tests.

- Conducted an experiment at Sandia's Z Pulsed Power Facility to produce relevant pressures regimes for research in high-energy-density science for measuring performance under shock conditions of potential threat materials that could be potentially used in a Nuclear Threat Device.
- Conducted the sixth and final underground conventional explosion of the Source Physics Experiment (SPE)
- Completed a five-year award to support nuclear security and nuclear science missions through the Nuclear Science and Security Consortium (NSSC), which included 307 researchers, 103 participants transitioning to careers in national laboratories and related national security service, and 246 publications and conference proceedings

Program Challenges

- Full integration of emerging interagency- identified priorities and requirements.

Nuclear Detonation Detection

The **Nuclear Detonation Detection subprogram** advances the underlying technical capability for detecting foreign nuclear weapon detonations, including meeting strategic military requirements and test ban treaty monitoring and verification needs. In this area, program plans are driven by requirements set in U.S. law for designing and building space-based sensors for the nation's operational nuclear test treaty monitoring systems and integrated threat warning/attack assessment capabilities. Additional needs-based research advances the nation's nuclear detonation detection capabilities through improvements in technical forensics, as well as seismic and radionuclide sensing, collection, and analysis. Particular focus includes providing the U.S. Government with increasing confidence in detecting, discriminating, and determining low yield events.

FY 2017 Accomplishments

- Delivered two sensor payloads—the GBD III-6 and III-7—to the U.S. Air Force.
- Fabricated three others sensor payloads—the GBD III-8, the Space and Atmospheric Burst Reporting System–3 (SABRS-3), and the Space and Endoatmospheric NuDet Surveillance Experimentation and Risk Reduction (SENSER) experimental payload—for delivery in FY 2018.
- Advanced geophysical modeling algorithms for extracting signals of interest from background.
- Improved nuclear forensics technical methods that better characterize SNM samples or nuclear detonations.

Program Challenges

- Mitigating supply-chain interruptions and meeting deliverables requiring special chip fabrication during a rapidly consolidating global manufacturing market.
- Design, procurement, production, and integration dependencies on the U.S. Air Force's yet-to-be-decided long-term acquisition strategy for geosynchronous sensing.

United States High-Performance Research Reactors

The **United States High-Performance Research Reactor subprogram** focuses on advanced LEU fuel qualification, fuel fabrication demonstration and commercial deployment, and reactor conversion regulatory analyses. This subprogram was transferred to DNN R&D per the 2017 Omnibus Appropriation, coordinating $53 million of activities with DNN's M^3 program.

FY 2017 Accomplishments

- Incorporated management responsibilities for the United States High-Performance Research Reactor program's LEU production, per the 2017 Omnibus Appropriation, coordinating $53 million of activities with DNN's M^3 program.

Program Challenges

- Integration of USHPRR program management requirements.

Nonproliferation Experiments at the Nevada National Security Site

Since 2010, when DOE/NNSA's 1,360 square mile Nevada Test Site was re-commissioned as the **Nevada National Security Site (NNSS)**, the site has hosted a diverse set of nuclear, energy, and homeland security activities by many U.S. Government agencies with national security responsibilities. DOE/NNSA has used the NNSS's inherent capabilities and remote location to develop national test beds in nonproliferation, nuclear explosion monitoring, arms control verification, and technical nuclear forensics. The two programs highlighted here, which are managed by **DNN R&D**, demonstrate a small part of the DOE/NNSA nuclear security work at NNSS.

Source Physics Experiments

The Source Physics Experiments (SPE) team, which includes scientists and engineers from **Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), the University of Nevada-Reno, the Air Resources Laboratory, the Desert Research Institute, and the NNSS** completed the final experiment of the six-experiment Phase I campaign to improve the United States' ability to detect and identify low-yield nuclear explosions. SPE-6 (October 12, 2016) was the shallowest of the SPE Phase I series and most similar in scaled depth of burial to the historic nuclear tests done at NNSS prior to the moratorium on nuclear testing in 1992. SPE-6 was a 2.2-ton (TNT equivalent yield) underground chemical explosion. It was placed 31.4 meters—or about 103 feet—deep in hard rock and measured 1.6 on the Richter scale. The next phase of the SPE tests planned for the next several years will focus on explosions in softer, less structured rock called alluvium, which will provide new information to improve understanding of issues relevant to monitoring nuclear explosions in these different geological conditions.

Weaponization Detection Experiments

A country conducts hydrodynamic experiments (i.e., compression and heating by chemical high-explosives [HE]) as a critical step in validating the performance of certain components in a nuclear weapon device. DNN R&D is conducting research to distinguish between the different signatures produced by HE dynamics during conventional detonations versus nuclear weapons-related detonations to improve our understanding of the nonproliferation value of all identified signals and our current predictive and assessment capacity. DNN R&D executed its most recent HE test from April 17 – May 19, 2017 at **NNSS**. This included nine high-fidelity detonations, each generating unique data sets that will expand signature of interest libraries and validate recently developed end-to-end simulations. In 2017, DNN R&D's predictive capability expanded from micro-second (µs)-micro-meter (µm) scales to second (s)-meter (m) scales, which will inform future sensor development and real event analysis. This collaboration was tightly integrated with DOE external stakeholders. Throughout the campaign, OGAs and DOD entities deployed remote (standoff) sensing capabilities whereas DNN R&D efforts focused on collecting close-in validation and early phenomena characterization data. Ultimately, the end-to-end simulation capability will assist stakeholders in their future operational missions and provide a one of kind capability to USG decision makers.

2.4.3 FY 2018 Future Years Program Plan

For FY 2018, DNN R&D will advance detection capabilities that address current and projected gaps in detecting the proliferation of nuclear weapons and diversion of SNM. DNN R&D activities for nonproliferation and foreign weapons program activity monitoring will include continued execution and development of national test beds for validation of new sensors, equipment, and capabilities. The DNN R&D program will support a broad set of nuclear nonproliferation and nuclear security initiatives for the detection of SNM production, safeguards, threat interdiction, and the underlying technical capabilities that support nonproliferation and counterterrorism/incident response requirements. The program will support payload-side technical integration, pre-launch, and on-orbit testing activities for previously delivered payloads in accordance with host satellite schedules. The DNN R&D program will continue to align with PPDs (e.g., PPD-33 and -42) and will conduct research in seismic, radionuclide, and detonation forensics, at lower nuclear yield levels, to support national capabilities in terrestrial and airborne monitoring and analysis methods.

Main Areas of Program Activity for FY 2018

- *Space-based Nuclear Detonation Detection*: Deliver NuDet detection satellite payloads in accordance with operational requirements and the negotiated schedule with the U.S. Air Force in order to detect, identify, and locate nuclear weapons detonations in the atmosphere and space.
- *Monitoring and Verification Field-Testing Program*: Develop predictive capabilities to detect low-yield and evasive testing globally via a comprehensive series of test beds, including those for Low-Yield Nuclear Monitoring, SPE, Nonproliferation Signatures, Underground Nuclear Event Signatures Experiments, High-Explosive Testing, and Uranium Solids Signatures.
- *Material Production Detection and Monitoring*: Develop and demonstrate capabilities for unilateral and cooperative detection and characterization of foreign nuclear weapons program activities, including SNM production via in-situ and remote means, safeguards applications, and a key interagency test bed.
- *Nuclear Weapons and Material Security*: Develop and demonstrate capabilities supporting nuclear security, including advanced detection and imaging for authentication and monitoring of warhead measurements, search, interdiction, and incident response, such as device diagnostics and stabilization tools with improved understanding of IND performance.
- *Nuclear Security*: Support nuclear and energetic materials characterization and advanced diagnostics.
- *University Program*: Continue the congressionally-directed IUP in support of basic research that is complementary to more applied national laboratory-based research and that acts as a conduit to migrate top talent toward technical applications at the national laboratories in national nuclear security. The IUP is a partnership between NNSA, NRC, and DOE's Office of Nuclear Energy.
- *Ground-based Nuclear Detonation Detection*: Advance NuDet monitoring network capabilities of ground-based systems, including seismic, infrasound, hydroacoustic, and radionuclide signatures. This activity provides advanced capabilities that are leveraged to improve the U.S. National Data Center and the U.S. Atomic Energy Detection System.
- *Nonproliferation Enabling Capabilities*: Advance simulations, algorithms, modeling, and data science that enable nonproliferation mission applications, as well as monitoring and verification technologies, and support a broad research and development base to bring new, crosscutting technologies to multi-use applications across NNSA and the interagency community.
- *Nuclear Forensics*: Continue DOE/NNSA research and development support to nuclear forensics, including research, technology development, and related science to improve pre- and post-detonation technical nuclear forensics capabilities, including developing and testing the technical means to help characterize environmental conditions that a bulk sample of SNM has recently experienced.

Approaches to Address Program Challenges

- The DNN R&D program uses technical expertise and stakeholder coordination to develop long-term, interagency vetted technology roadmaps, in order to achieve the top-level multi-year goals and milestones identified below.

Multi-Year Goals

- *Demonstrate Improvements in Detection and Characterization of Nuclear Weapons Production:* This effort began in FY 2014. The goal reflects a multi-year campaign to demonstrate a specific set of next generation technologies, but research and development in this area addresses an enduring need that will continue after this campaign is completed. The projected completion date for the multi-year goal is FY 2018.
- *Demonstrate Improvements in Nuclear Weapons and Material Security*: This effort began in FY 2014. The goal reflects a multi-year campaign to demonstrate a specific set of next generation technologies, but research and development in this area addresses an enduring need and will continue after this campaign is completed. The projected completion date for the multi-year goal is FY 2018.
- *Develop advanced capabilities for detecting and monitoring foreign nuclear weapons development and material production.* This effort will begin in FY 2018.
- *Maintain the nation's space-based global nuclear detonation detection capability by delivering scheduled sensor payloads and supporting payload-side integration, pre-launch, and post-launch testing*. This is an ongoing effort with a mix of design, production, and testing activities each year.

2.5 Nonproliferation Construction Program

2.5.1 Program Strategy, Priorities, and Performance Metrics

The Nonproliferation Construction program consolidates the construction costs for DOE/NNSA nuclear nonproliferation programs, which primarily are the construction projects associated with U.S. plutonium disposition efforts.

Plutonium disposition is one of the largest activities within the DNN portfolio, with a scope that includes construction projects, plutonium oxide conversion campaigns at two different sites, and a number of smaller supporting activities. The United States has committed to disposing of 34 MT of weapon-grade plutonium. Although the U.S. approach has been to dispose of this plutonium by fabricating it into MOX fuel and irradiating that fuel in light water reactors, as a result of a number of cost and program reviews it is now clear that this will cost more and take longer than initially anticipated. As a result, DOE/NNSA has proposed to terminate the MOX approach to plutonium disposition and pursue the dilute and dispose approach. Under the new approach, the plutonium can be disposed of decades sooner than the MOX approach, at less than half the cost and with far lower technical risks. The new approach will enable the Department to be more responsible stewards of taxpayer dollars while upholding our commitment to dispose of surplus plutonium.

This decision has been made as a result of careful consideration and detailed analyses, including several studies by experts both inside and outside of the Department. As part of DOE's efforts to improve the efficiency of the plutonium disposition mission, the DOE Plutonium Disposition Working Group (PWG) was established in June 2013, to conduct a detailed analysis of options for the disposition of surplus plutonium. In April 2014, the PWG issued its report titled *Analysis of Surplus Weapon-Grade Plutonium Disposition Options*.

The 2014 PWG report identified one option, dilution and disposal in a repository, that is technically viable, less expensive, and of relatively low risk as compared to the MOX fuel option. The dilute and dispose option involves diluting plutonium oxide with inhibiter materials, packaging it into approved containers, and shipping the diluted plutonium to a repository for permanent disposal. The Department already has disposed of over 4 MT of plutonium at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, NM, using this dilution and disposal method, demonstrating the feasibility of this approach.

Following the release of the 2014 PWG report, the *Consolidated and Further Continuing Appropriations Act 2015,* directed that construction continue on the MOX Fuel Fabrication Facility at DOE/NNSA's Savannah River Site, in Aiken, SC, and that additional cost studies and technology alternative studies be conducted. The *National Defense Authorization Act for FY 2015* also mandated an independent assessment and validation of the 2014 PWG analysis.

The Department tasked the Aerospace Corporation, a Federally Funded Research and Development Center, to conduct these congressionally-mandated assessments. In April and October 2015, Aerospace Corporation completed two reports documenting its assessments of the 2014 PWG analysis. Additionally, in June 2015 the Secretary of Energy assembled a Red Team to assess options for the disposition of surplus weapon-grade plutonium. The Red Team was comprised of 18 experts, including both current and former employees of Savannah River National Laboratory, Los Alamos National Laboratory, Idaho National Laboratory, Sandia National Laboratories, Oak Ridge National Laboratory, the United Kingdom National Nuclear Laboratory, and the Tennessee Valley Authority, as well as private nuclear industry and capital project management experts.

Both the Aerospace Corporation and Red Team assessments confirmed that the MOX fuel approach will be significantly more expensive than anticipated. The MOX fuel approach is expected to require approximately $800 million to $1 billion in funding annually for decades. Moreover, both assessments confirmed that even the best-case scenario for the MOX fuel approach would be riskier and more expensive than the worst-case scenario for the dilution and disposal approach.

In FY 2016, as directed in the Consolidated Appropriations Act, the Department began advance planning on the dilute and dispose approach. DOE intends to submit a report to the Committees on Appropriations of both Houses of Congress that includes an evaluation of program risks and a lifecycle cost estimate and schedule for the alternative once completed. Additionally, as directed by the *National Defense Authorization Act for FY 2016*, the Department has completed an updated Performance Baseline cost estimate for the MOX facility. Using the U.S. Army Corps of Engineers' recent estimate of $17.2 billion, there is $12.3 billion to go and estimated construction completion in 2048.

2.5.2 FY 2017 Activities, Accomplishments, and Challenges

In FY 2017, the Department carried out the following activities to advance the dilute and dispose approach:

- Completed conceptual design for the Surplus Disposition Project in support of the dilute and dispose strategy.

2.5.3 FY 2018 Future Years Program Plan

Multi-year goals and associated performance targets are currently being adjusted to reflect the planned dilution and disposal approach to plutonium disposition. Some of the major future-year milestones will be to:

- Seek Critical Decision 1 approval to begin the preliminary design for the Surplus Plutonium Disposition project at the Savannah River Site to support the dilute and dispose strategy.
- Complete the proposed termination plan of the MOX Fuel Fabrication Facility project upon congressional approval.

Chapter 3: Counter
Countering Nuclear/Radiological Proliferation and Terrorism

***Counter** the efforts of both proliferant states and non-state actors to steal, acquire, develop, disseminate, transport, or deliver the materials, expertise, or components necessary for a nuclear weapon, an improvised nuclear device, or a radiological dispersal device.*

3.1 Program Strategy, Priorities, and Performance Metrics

The Office of Counterterrorism and Counterproliferation (CTCP) reduces the threat of nuclear proliferation and nuclear and radiological terrorism through innovative science, technology, and policy solutions. CTCP's Nuclear Counterterrorism (NCT) activities focus on reducing the risk of terrorist acquisition or use of nuclear devices and materials. This is supported by a robust technical understanding to characterize, detect, and defeat the range of nuclear threat devices that a non-state actor could potentially construct. CTCP uses this specialized knowledge of nuclear threat devices to inform U.S. and international policy relating to nuclear counterterrorism and counterproliferation. These policies cover a broad spectrum, including security recommendations and standards for nuclear material storage and transport, search and detection, nuclear incident response, nuclear forensics, and other technical and policy work in the nuclear threat arena.

One of the primary technical activities of the CTCP program is to evaluate the vulnerability of nuclear materials that could be exploited in an IND and provide the U.S. Government with accurate assessments of the functionality of various IND configurations. CTCP also develops tools and procedures for rendering safe an IND and understanding forensic signatures following a detonation. As a result, CTCP's technical and scientific understanding of nuclear threat devices and nuclear materials actively influences emergency response policies at the federal, state, and local levels and contributes to the development of long-term SNM disposition options. Additionally, CTCP's nuclear counterproliferation efforts consist of strategies employed after proliferant states have obtained nuclear materials, technologies, or devices. CTCP leads these missions across DOE/NNSA, generating scientific knowledge that influences a wide range of domestic and international security policies and practices.

In late 2015, CTCP assumed responsibility for several functions previously executed by the Office of Emergency Operations, including nuclear incident response, nuclear forensics, and international emergency management and cooperation (IEMC). CTCP has fully integrated these capabilities and expertise in support of the greater DOE/NNSA mission. With the addition of these subprograms, CTCP now provides the U.S Government's foremost technical capability to understand, characterize, counter and respond to, and attribute nuclear threats and incidents, anywhere in the world.

3.1.1 Developing Technical Understanding of Threat Devices

Nuclear Threat Device Assessment

The NCT program advances U.S. counterterrorism and counterproliferation objectives through innovative science, technology, and policy-driven solutions. NCT activities (a) reduce the risk of terrorist acquisition or use of nuclear devices and materials, as well as (b) develop the technical understanding required to characterize, detect, and defeat the range of nuclear devices potentially available to a non-state actor. Nuclear counterproliferation consists of strategies employed after state actors have (or are presumed to have) obtained nuclear materials, technologies, or devices. The NCT program leads these missions across NNSA and influences a wide range of policies both domestically and internationally.

In addition to identifying the theoretical design space for INDs, the NCT program is responsible for understanding other nuclear threat devices, such as nuclear devices of proliferation concern and nuclear weapons outside of state control. This vital program relies on specialized device modeling and simulation capabilities, as well as the vast science and technology experience base of the U.S. nuclear weapons complex, to advance the nation's technical knowledge of these devices, including IND designs, concepts, and related manufacturing or processing pathways.

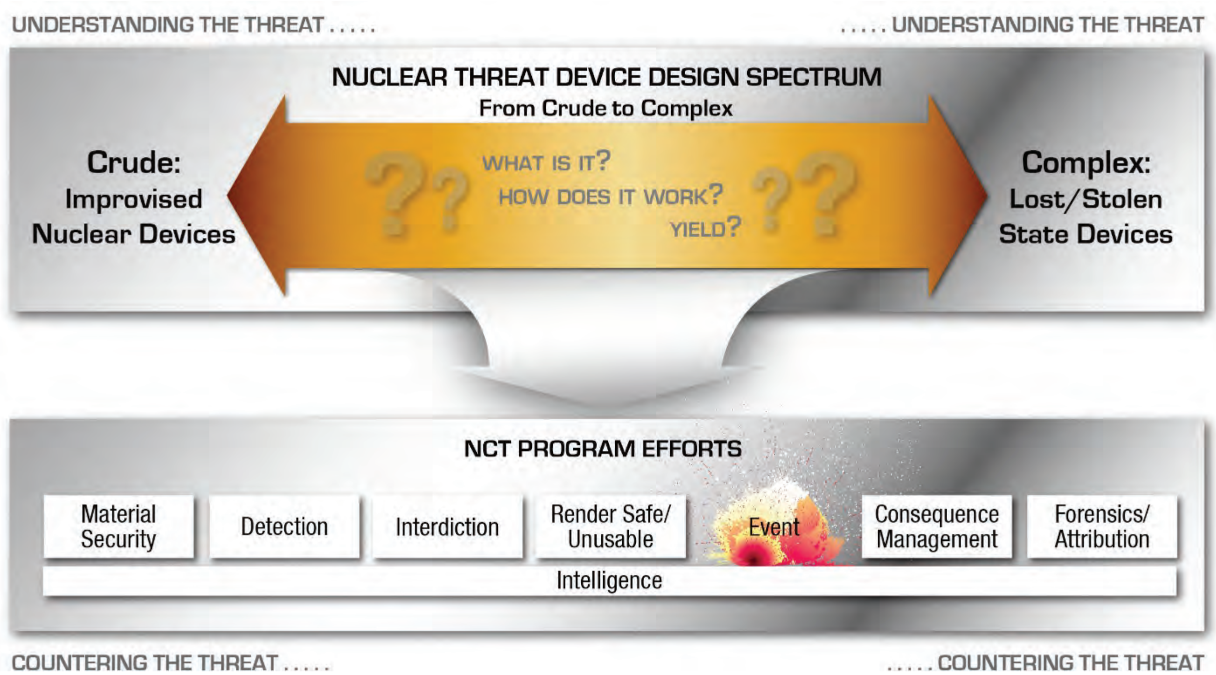


Figure 13. Understanding the Threat Across the "Nuclear Threat Device Design Spectrum"

The NCT program works to understand the full range of potential nuclear threat device designs, from a relatively simple IND, to a lost or stolen complex nuclear weapon state weapon. There are significant uncertainties associated with the design spectrum because it is difficult to predict the exact nature of the threat (i.e., device composition) prior to discovery. These uncertainties directly impact the ability to detect, interdict, and render safe a device before a nuclear event, as well as the consequence management, technical forensics, and attribution efforts following a detonation.

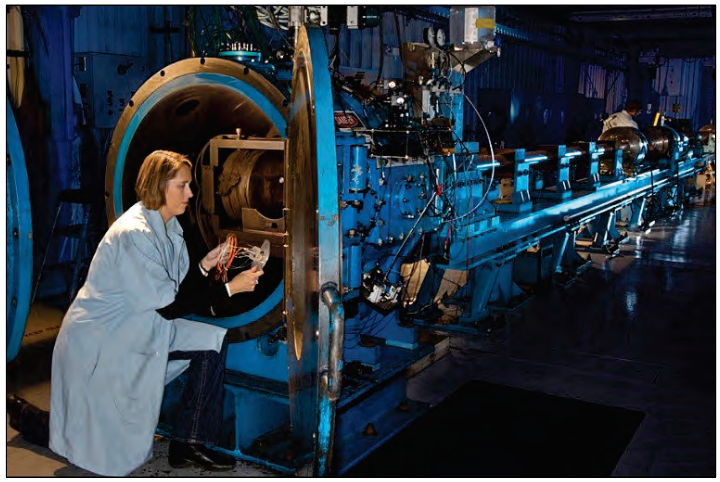


Figure 14. Experimental Facilities Help Deepen Technical Understanding of Nuclear Threat Device Performance

The knowledge generated by the NCT program actively informs a range of U.S. Government NTR policies, including detection and interdiction practices and emergency response operations. The latter activity, in particular, is strongly influenced by the NCT program's understanding of IND design configurations. This knowledge dictates the optimal means of rendering safe a nuclear device, as well as predicting the potential consequences of such operations. Additionally, the NCT program supports the development of purpose-built tools to neutralize these devices, distributing them to various U.S. Government operators and training them in their use. As a result, emergency response planning at every level of the government is directly influenced by NCT's technical knowledge.

Standoff Disablement

At DOD's request, and in support of U.S. national policy objectives, the NCT program conducts technical assessments for innovative approaches to degrade or disable nuclear devices. The NCT program gathers existing experimental and other data, identifies information and modeling gaps, and develops the ability to predict the behavior of non-stockpile nuclear materials or components in response to these innovative approaches. This activity includes experimental and computational investigations that improve confidence in modeling capabilities. The results of these assessments will be used to determine future U.S. Government efforts in the standoff disablement mission space.

Materials Characterization

DOE/NNSA performs a unique national security mission for the U.S. Government: the study of the basic physical properties of materials to determine their utility in nuclear threat devices. This activity uses nuclear warhead stockpile tools that the DOE/NNSA nuclear weapons laboratories developed over several decades to build and service the U.S. nuclear arsenal. DNN R&D analyzes nuclear materials through an extensive research and experimentation campaign to enable effective U.S. Government responses to their potential use in a nuclear device on behalf of the NCT program.

The technical understanding generated by this material characterization activity provides crucial insights that inform a large number of policies relating to nuclear security. One notable application of this knowledge is the NCT program's technical guidance concerning efforts to reduce the "attractiveness" of nuclear materials, where attractiveness is defined as material characteristics (e.g., physical form, weight) that make them desirable to illicit actors.

NCT program guidance is used to determine physical protection standards for nuclear materials to ensure that they are kept beyond the reach of criminals, terrorists, or other adversaries. Combining materials characterization and other skill sets, the NCT program continues to improve key nuclear forensics modeling efforts at DOE national laboratories in support of threat device attribution.

Policy Engagement

Policy engagement with both the U.S. interagency and international partners is a cornerstone of the NCT program's mission. Indeed, the fundamental purpose of the office's development of technical knowledge is to facilitate technically informed policymaking to counter the threat of nuclear terrorism and nuclear proliferation.

DOE/NNSA Collaboration. The nuclear counterterrorism and counterproliferation mission affects many organizations across the greater DOE/NNSA complex. Many of the initiatives of the NCT program depend on the implementation of consistent policies, an efficient use of resources, and a coordination of efforts. The NCT program's unique technical expertise drives this cooperation at all DOE/NNSA facilities, to include headquarters, the national laboratories, plants, and sites.

U.S. Interagency Engagement. Domestically, policy engagement spans the U.S. interagency, providing technical insights to DOD, Department of Justice (DOJ), DHS, NRC, and the U.S. Intelligence Community. In this role, the NCT program serves as the central clearinghouse for technical knowledge relating to nuclear threat devices within the U.S. Government. In many cases, the knowledge that the NCT program possesses has led to significant changes in assumptions about the ability of terrorists to build a nuclear device. This enhanced understanding of what terrorists may be technically capable of achieving has driven domestic nuclear materials protection, intelligence collection requirements, radiation detection specifications, and emergency response doctrine. More broadly, this enhanced appreciation of the realm of the possible with respect to nuclear threat devices has influenced U.S. national security priorities, adding renewed urgency to the effort to secure WUNM worldwide.

Bilateral Exchanges. The United States and the United Kingdom share a long history of scientific and technical cooperation to reduce the threat of nuclear terrorism and proliferation. This bilateral exchange has been successfully managed by DOE/NNSA and DOD and by the Ministry of Defence for the United Kingdom. Likewise, DOE/NNSA conducts exchanges with France's *Commissariat à l'énergie atomique et aux énergies alternatives*, sharing scientific insights and collaborating to address global nuclear threats. These exchanges occur under a separate Mutual Defense Agreement with each country.

P3 Exchanges. In addition to bilateral NTR relationships, the United States, United Kingdom, and France (P3) maintain a program of enhanced technical collaborations on a wide range of NTR subjects. The three nations have established a framework for cooperation on incident response and crisis management, nuclear energy and materials security, and sharing of threat-related information. These exchanges have had far-reaching effects not only on the policies of the three countries, but also on international nuclear security policy.

Other International Outreach. The NCT program's technical knowledge is shared internationally in support of a variety of missions, including influencing the protection standards surrounding global stocks of nuclear material. A key purpose of the NCT program's international exchanges is to apprise foreign governments, agencies, and commercial entities of the risk of nuclear terrorism and the policies they can implement to lessen this risk. These activities must be closely informed by highly sensitive science and technology knowledge. One such international collaboration is the Nuclear Security Working Group with Japan, which addresses the nuclear terrorism threat to Japan's civil nuclear sector. As part of this effort, the office coordinated a joint technical study with Japan to identify potential approaches to reduce the attractiveness of various civil nuclear materials that could be used for malevolent purposes. In 2016, the two countries conducted a joint technical impact study to evaluate the cost and engineering challenges associated with the options identified.

3.1.2 Strengthening WMD Counterterrorism and Nuclear/Radiological Incident Response Capabilities and Preparedness at Home and Beyond

An act of nuclear or radiological terrorism, or even a nuclear accident, will have repercussions for all countries, regardless of where such an incident takes place. Additionally, nuclear and radiological incidents and emergencies, while relatively infrequent, have shown that any country's capabilities and resources can be quickly overwhelmed. Timely (and often international) responses are required to minimize consequences. Recognizing this shared and global threat, another CTCP mission is to strengthen nuclear and radiological counterterrorism, accident and incident preparedness, and response capabilities. CTCP's nuclear incident policy and cooperation activities focus on domestic preparedness—as a first priority—and the overseas preparedness and response skills required for a prompt, effective, and coordinated response to nuclear and radiological incidents at their origin.

These nuclear incident preparedness and response strategic engagements derive from DOE/NNSA's statutory counterterrorism and incident response responsibilities and are designed to advance key national security strategies, national security policies, and U.S. Government objectives related to domestic and international nuclear incident preparedness and response, including to potential terrorist threats. The program's strategic objectives are:

- **Advance** U.S. Government nuclear-related objectives at home and abroad, by strengthening and harmonizing global nuclear and radiological incident preparedness and response capabilities.
- **Enhance** foreign whole-of-government preparedness and response coordination, especially highlighting the role of technical expertise in this regard.
- **Expand** relevant insights for domestic operational response capabilities, experience, and approaches through joint engagements, exercises, and technical studies.
- **Improve** global awareness of nuclear and radiological terrorism threats and promote the Department's (and other) emergency reach-back resources for all radiological emergencies.

These strategic engagements can include unclassified and classified technical exchanges, joint experiments, technical capability inter-comparisons, and joint operational trainings and exercises to strengthen nuclear preparedness and response. These mutually beneficial engagements strengthen the national, bilateral, and regional capabilities and coordination needed to quickly recognize, characterize, and respond to the broad range of nuclear and radiological threats.

To assess and prioritize both domestic and bilateral strategic engagements, the nuclear incident and policy cooperation program annually assesses potential partners to determine relative CTCP priorities. Using a proprietary, unclassified methodology, CTCP incorporates a variety of authoritative, third-party terrorism, economic, and societal factors. Domestically (at the city and state levels), U.S. states and metropolitan areas are assessed on a relative basis by considering a number of factors associated with possible human, economic, and other impacts of a WMD terrorism incident. Internationally (at the national level), countries are assessed on a relative basis using a number of factors associated with terrorism incidence, governance, and security. As a next step, CTCP considers applicable policy and practical considerations to prioritize and guide the program's strategic partnerships.

The program's formal metrics assess the breadth of NCT outreach programs, using annual targets for the number of federal, state, and local officials trained by NCT. NCT exceeded its goal to have trained a cumulative 12,500 officials by the end of FY 2017; the FY 2020 training target is a cumulative 14,800 officials.

The NCT program works with other U.S. Government agencies in conducting counterterrorism tabletop exercises (TTXs) and security dialogues with domestic and foreign partners, so as to enhance their preparedness and help counter nuclear and radiological terrorism threats.

WMD Counterterrorism Tabletop Exercises

The WMD Counterterrorism Tabletop Exercise (WMD CT TTX) program designs, produces, and conducts tailor-made TTXs in order to increase WMD counterterrorism awareness and capabilities, both domestically and internationally. Since its start in 1999, the WMD CT TTX program has trained over 10,000 federal, state, local, and foreign officials via 120 different WMD counterterrorism, prevention, and response exercises across the United States and in key international partner nations. All exercises are open-source, and without evaluation or attribution, in order to maximize full participation and practical value to participants.

Domestically, as part of a cost-share collaboration between DOE/NNSA's GMS program and the FBI's WMD Directorate, the NCT program designs, produces, and conducts the *Silent Thunder* series of site-specific TTXs at U.S. private- and public-sector locations with civil nuclear or radioactive sources. The *Silent Thunder* exercises bring together federal, state, and local agencies, and on-site officials charged with security, emergency preparedness, and emergency response functions to practice their response to a hypothetical, custom-designed attack scenario. The WMD CT TTX program's *Eminent Discovery* exercises and other international TTXs similarly focus on strengthening WMD counterterrorism capabilities of foreign partners through familiarization with, and exercise of, international recommendations and best practices as well as relevant national legal frameworks and standard operating procedures. Conducted in partnership with the Chemical, Biological, Radiological, and Nuclear (CBRN) Commodity Identification Training activity (managed by NPAC's Nuclear Export Control program), the *Eminent Discovery* exercise series sensitizes participants to the WMD terrorism threat while strengthening officials' coordination and communication skills needed to interdict WMD-related commodities being trafficked for terror purposes.

Counterterrorism Security Dialogues

Beyond capacity-building, the Counterterrorism Security Dialogues (CTSDs) use bilateral classified and/or sensitive information-sharing agreements to conduct standing, senior-level interagency discussions with advanced civil nuclear partners on non-state actor threats to nuclear facilities and materials. These unique information-sharing agreements allow for an open and robust exchange in counterterrorism security cooperation. CTSDs cover such topics as nuclear terrorism threat assessments, best practices, technical approaches, and tools to reduce terrorist risks to nuclear facilities and material transports, relevant counterterrorism policy and standard operating procedures, and reciprocal observations and peer assessments of national-level nuclear exercises and training. These mutually beneficial bilateral CTSDs foster regular discussions between senior interagency teams responsible for various aspects of nuclear security and WMD counterterrorism. Efforts also focus on exchanging, as appropriate, advanced technical capabilities and expertise resident within DOE and the national laboratories to address the shared nuclear terrorism threat.

3.2 FY 2017 Accomplishments and Challenges

FY 2017 Accomplishments

- Executed a full range of threat device and standoff disablement modeling and experiments, and continued the development and testing of render safe tools, with accelerated experimentation continuing through FY 2018.

- Continued to support international P3 and bilateral collaboration activities through the NTR channels on technical and scientific reach-back capabilities and work plans.
- Conducted seven domestic *Silent Thunder* WMD CT TTXs, seven *Eminent Discovery* TTXs or WMD Threat Awareness workshops, and two classified CTSDs to address evolving and emerging terrorism threats to nuclear materials and facilities.
- Concluded one bilateral joint technical study on characterizing radiological terrorism consequences and informing radiological terrorism response approaches.
- Planned a bilateral follow-on to the *Apex Gold* Scenario Based Policy Discussion for execution in 2018.
- Continued executive military education efforts, in conjunction with the DOD and Special Operations Command regional engagements, to strengthen preparedness and response skills for radiological terrorism.

Program Challenges

- Ensuring necessary coordination and synchronization of efforts within DOE/NNSA, across the U.S. interagency, and with international partners. This collaboration is necessary to continue to meet current or emerging needs of the U.S. Intelligence Community, DOD, and the FBI.
- Balancing the demands of the mission with resource constraints, while fostering continued support by U.S. Government and international partners to maintain the program results.
- Efficiently and effectively leveraging the technical expertise to improve capabilities and policies with appropriate U.S. Government and international partners and organizations.

3.3 FY 2018 Future Years Program Plans

For FY 2018, NCT will sustain nuclear threat device assessment capabilities and expertise, including unique modeling efforts. Additionally, NCT is focusing on evaluating response options when appropriate, sustaining the measures to protect IND design information, and managing the assessment of open-source information. NCT also will sustain international technical and policy engagements through the NTR channels. In addition, the program will support bilateral CTSDs with advanced civil nuclear partner countries and conduct outreach to strengthen WMD counterterrorism capabilities domestically and abroad.

The NCT long-term priorities are to improve and sustain the ability to understand nuclear threats by improving NCT capabilities and applying NCT knowledge to enhance the operational capabilities of key partners. NCT goals are centered on improving the ability to assess nuclear threat devices and inform national and international policy decision-making processes to minimize the possibility of a nuclear detonation or nuclear terrorist event.

NCT goals also include innovative approaches for standoff disablement through experiments and computational modeling, thus meeting key DOD needs in support of national policy objectives. Additional NCT goals include strengthening nuclear counterterrorism capabilities and awareness through WMD counterterrorism outreach focused on the expertise, coordination, and communication required to address nuclear or radiological terror threats associated with nuclear or radiological facilities or materials. Additionally, NCT will maintain post-detonation nuclear device modeling and data evaluation capabilities.

Main Areas of Program Activity for FY 2018

- Continue the activities supporting the scientific understanding of INDs and management of classified threat device information.
- Conduct modeling, experiments, and simulations of a variety of technical topics, to include threat devices, nuclear materials attractiveness, high explosives, standoff disablement, post-detonation, and render safe.
- Support collaboration activities with international partners and organizations, as well as continue materials attractiveness efforts under the U.S./Japan Nuclear Security Working Group.
- Expand conduct of domestic *Silent Thunder* nuclear/radiological TTXs and international WMD counterterrorism TTXs to additional, priority partners.
- Strengthen counterterrorism capabilities and reduce non-state actor threats to nuclear facilities and materials by conducting CTSDs with key advanced civil nuclear countries.
- Develop, design, organize, and conduct specialized emergency management training courses and programs to meet the specific emergency management needs of six additional/new priority partner nations.

Chapter 4: Respond
Responding to Nuclear/Radiological Threats and Terrorism

Respond ***to nuclear or radiological incidents by searching for and rendering safe threat devices and materials; carrying out nuclear forensic activities; conducting consequence management actions following an event to protect lives, property, and the environment; and preparing for and supporting departmental emergencies through close coordination with the Department's Emergency Management Enterprise system.***

Under DOE/NNSA's NTR mission, the Deputy Under Secretary for Counterterrorism and Counterproliferation and the Associate Administrator for Emergency Operations have primary responsibility for the "respond" functional area. Together, these offices coordinate efforts to reduce the risk of nuclear and radiological terrorism and enhance the Department's overall emergency preparedness. These organizations strive to diminish the value of nuclear or radiological weapons and devices to terrorists and proliferant states through the capability to respond to, manage, avert, and contain the consequences of nuclear and radiological incidents in the United States and elsewhere in the world.

The Department's emergency response capability includes a number of specialized nuclear and radiological crisis response and consequence management teams and assets—maintained by CTCP—that are equipped and trained to identify, characterize, render safe, and dispose of nuclear and radiological devices or mitigate the consequences of a nuclear or radiological incident.

In support of U.S. Government efforts to conduct nuclear/radiological emergency response and threat related operations, DOE/NNSA engages its crisis operations, consequence management, and emergency management core missions and associated capabilities. **Crisis Operations** refer to the set of DOE/NNSA programs and missions focused on preventing and protecting the United States and its allies from threats and adversaries associated with nuclear/radiological materials and devices. Working together with other departments and agencies, such as FBI, DHS, DOD, and others, the crisis operations program and its missions encompass searching for, locating, assessing, and making safe nuclear and radiological materials and devices. **Consequence Management** refers to the set of DOE/NNSA missions focused on responding to both accidental and intentional releases of radioactive materials that can harm people, property, and the environment. Like crisis operations, the consequence management program and its missions work with, and oftentimes support, the departments and agencies listed above, as well as the Environmental Protection Agency (EPA), the NRC, and state and local governments. These consequence management missions encompass a wide range of modeling, technical assessment, and operational support disciplines. The products are used to support incident commanders responding to both DOE on-site and nationwide events, with a focus on saving and sustaining lives and minimizing the effects of contamination on both infrastructure and the environment following a nuclear/radiological incident.

The **Emergency Management** program and its missions ensure that nuclear/radiological emergency management and response capabilities are in place and effectively integrated to respond to any DOE and NNSA facility emergency events. The program and its missions also are responsible for developing and

Figure 15. Aerial Radiation Measurement Survey Mission

promulgating emergency management, Continuity of Operations (COOP), and Continuity of Government (COG) policy and guidance across DOE and NNSA. Together these missions and capabilities provide a range of critical emergency response expertise to the United States across the informed emergency preparedness spectrum defined in PPD-8 to include prevention, protection, mitigation, response, and recovery.

The Department's Emergency Management Enterprise is closely coordinated with federal, state, tribal, and local agencies. This coordination is guided by interagency directives, including PPD-8. This directive requires the development of National Planning Frameworks, which set national strategy and doctrine for emergency preparedness, as well as Federal Interagency Operational Plans, which integrate and synchronize capabilities across federal agencies.

4.1 Crisis Operations

4.1.1 Program Strategy, Priorities, and Performance Metrics

The Crisis Operations mission is to organize and maintain an agile, scalable, and rapidly deployable response capability in support of nuclear or radiological crisis prevention, protection, and associated mitigation functions. Program objectives include providing preeminent, national-level nuclear and radiological science and technology expertise during the deployment and conduct of detection and search operations, device stabilization, and render safe operations. DOE/NNSA teams provide crisis operations technical expertise to assist U.S. federal, state, tribal, and local law enforcement agencies. DOE/NNSA deployable personnel also serve as the information conduit to DOE/NNSA command, control, and coordination elements during crisis operations.

Additionally, DOE/NNSA provides specialized crisis operations support to foreign nations and international organizations in the areas of nuclear/radiological search, emergency response management, and reach-back support for triage and medical assistance, through the conduct of formalized training courses and long-term detection equipment loan programs.

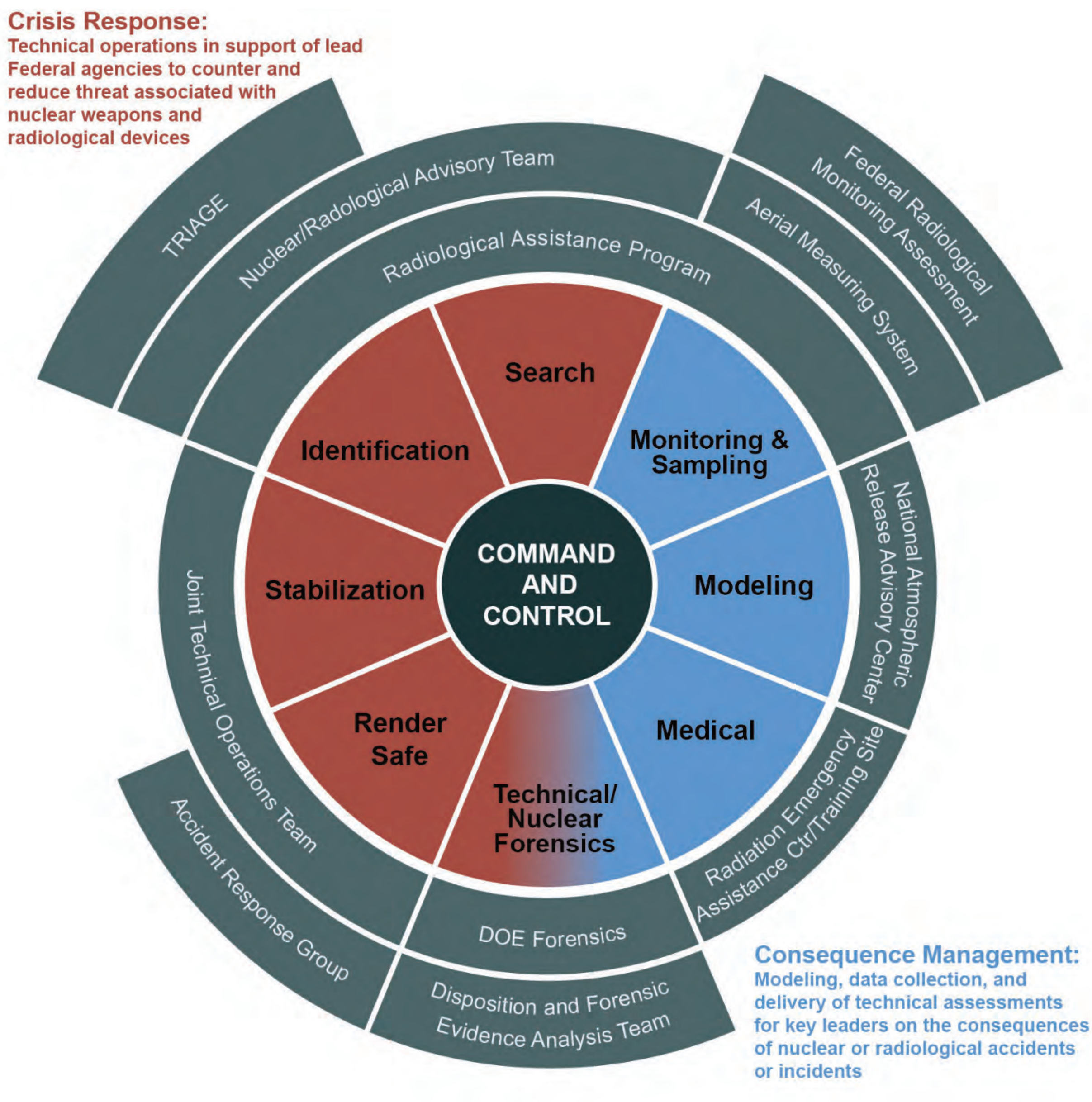


Figure 16. DOE/NNSA Emergency Response Assets

4.1.2 FY 2017 Activities, Accomplishments, and Challenges

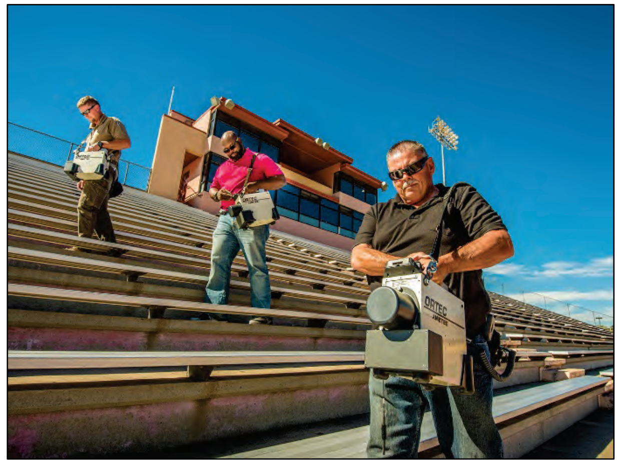


Figure 17. Nuclear/Radiological Advisory Team (NRAT)

DOE/NNSA provides technical support to DHS, FBI, and DOD to respond to incidents, including terrorist threats involving nuclear materials. The primary missions of the technical teams are to search for, identify, characterize, render safe, and dispose of any nuclear or radiological device. Two of these DOE/NNSA technical assets support FBI search missions: the Nuclear/Radiological Advisory Team (NRAT) and the Radiological Assistance Program (RAP) teams. NRAT is the primary technical support to the FBI in conducting radiological search missions. NRAT provides continuous, on-call nuclear and radiological expert advice and operational support from two locations: Washington, DC and Las Vegas, NV. The RAP is the primary technical support to the FBI's regional radiological search missions and provides radiological emergency first-response capabilities to federal, state, and local governments. The RAP provides continuous on-call technical response and advice, exploiting the expertise and knowledge from the DOE complex.

Detection and Search

DOE/NNSA subject matter experts provide technical assistance to the FBI for all radiological search missions and to other federal, state, tribal, and local law enforcement agencies in the detection, identification, analysis, and response to events involving the potential loss and/or theft of nuclear/radiological materials and devices. U.S. policy directive PPD-25 designates DOE/NNSA as the technical lead for U.S. interagency Tactical Nuclear/Radiological Search Operations (TRNSOs). DOE/NNSA employs the unique expertise of the U.S. nuclear security complex during nuclear/radiological search operations by assessing the technical characteristics of the threat; recommending tactics, equipment configurations, resource tracking, and allocation during the planning and operational phases; and tracking status, adjudicating anomalies, and conducting technical briefings during execution. DOE/NNSA activities are fully integrated with U.S. law enforcement and provide for responder health and safety, protection of classified materials and data, and the seamless transition to render safe or consequence management operations.

DOE/NNSA's RAP—which has locations near nine DOE national laboratories—provides continuous technical response, support, and advice to the FBI. DOE/NNSA supports search field elements with a dedicated search home team node that provides technical assistance in support of the larger Crisis Response Home Team.

DOE/NNSA supports the FBI-led process to evaluate CBRN threats in the event of a nuclear or radiological threat. Upon determination that the threat is credible, a course of action will be determined by assessing the potential impact of the threat. DOE/NNSA is integrated into the FBI-led planning efforts and leads technical/scientific evaluations and consequence management.

The identification and resolution of radiation alarms is a major pillar of DOE/NNSA support. Radiation anomalies discovered in the environment are usually benign, but in the event of a threat, each must be assessed carefully. Accurate identification, therefore, requires expert analysis. The DOE/NNSA Triage program is the world's preeminent program to analyze field-collected radiation data. Triage is staffed by

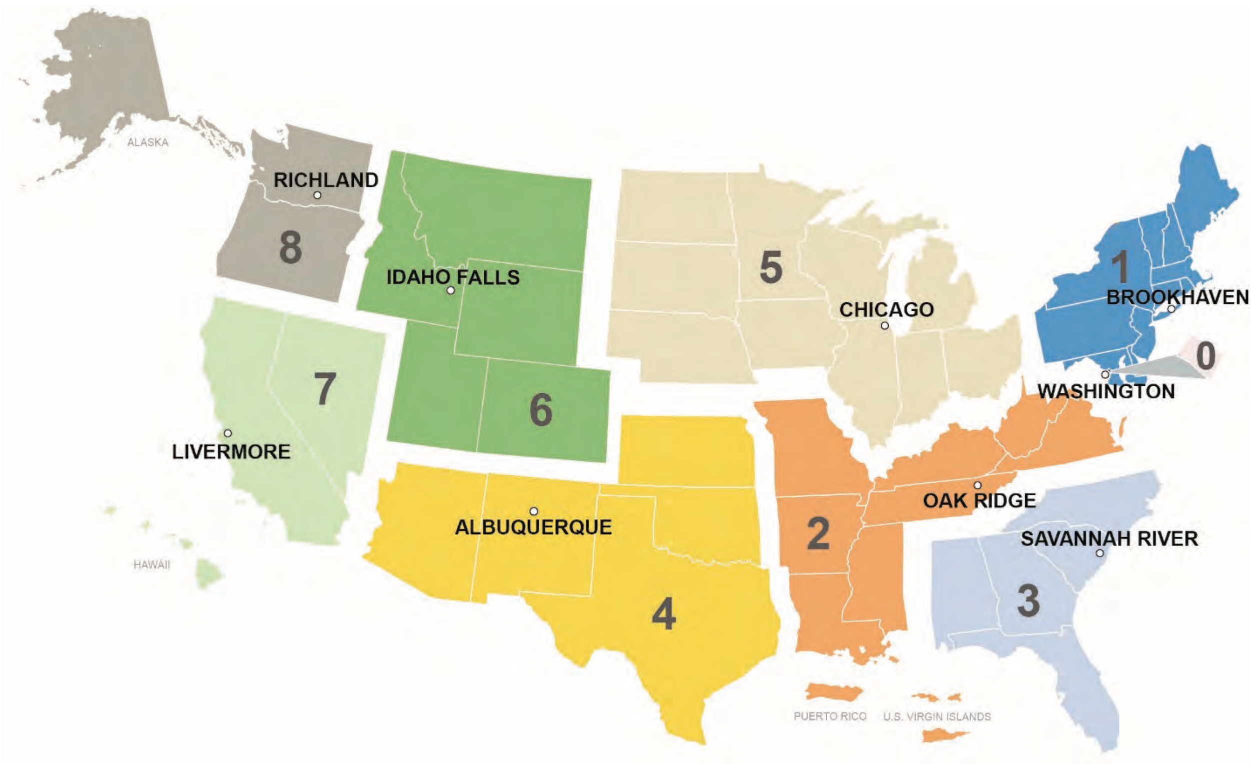


Figure 18. NNSA RAP Team Regions and Locations

U.S. national laboratory scientists and engineers with specialized skills to analyze data and perform radioisotope identification.

DOE/NNSA also provides technical radiological search support to national- and regional-level special security events, including political gatherings, such as the Republican and Democratic National Conventions, the United Nations (UN) General Assembly, U.S. State of the Union Address, and large public events such as the Olympics, the Super Bowl, and major-city New Year's Eve celebrations.

DOE/NNSA has forged effective mechanisms for mitigating the effects of a nuclear incident anywhere in the world to strengthen the emergency management system with international reach-back capabilities that include both the International Exchange Program for plume modeling and effects and radiological triage for technical analysis. Radiation detection equipment is provided to foreign partners through this program to improve and enhance radiation detection and to ensure necessary capabilities are in place to effectively respond to any nuclear/radiological event. Equipment provided on long-term loan includes the Spectral Advanced Radiological Computer System (SPARCS) for aerial and ground operations, radiation pagers, backpacks, identi-FINDERS (hand-held instruments that quickly detect, locate, and identify radiation sources), and health physics kits.

Render Safe

The DOE/NNSA Stabilization and Render Safe programs provide technical assessments, training, and operational support to the FBI and DOD to prevent nuclear terrorism, using technology and the application of special methods and tools to characterize and neutralize nuclear and radiological devices. DOE/NNSA's render safe teams have the specialized personnel and equipment necessary to assess, analyze, and provide technical advice to the U.S. Government's national WMD render safe capability, in support of disabling the weapon or device and making it ready for packaging and movement to a secure location.

The FBI has primary responsibility to respond to terrorism involving an IND, RDD, or other WMD within the continental United States. DOD has primary responsibility to respond to terrorism involving an IND, RDD, or other WMD outside the continental United States (OCONUS), via SMUs and Geographic Combatant Commands. DOE/NNSA's Render Safe Program provides technical assistance, training, and operational support to the FBI and DOD through technology and the application of special methods and tools to interrupt the functions of IND and RDD threat devices.

DOE/NNSA's Accident Response Group (ARG) provides technical guidance and weapons damage assessments, and supports development and implementation of safe weapon recovery, packaging, transportation, and disposal procedures. The mission of the ARG is to maintain readiness to respond to and manage the resolution of accidents or incidents of significance that involve U.S. nuclear weapons and classified nuclear weapon components. The ARG staff includes scientists, engineers, technicians, health physicists, and safety specialists from the DOE national laboratories, and highly specialized state-of-the-art equipment for use in monitoring, assessing, and recovering nuclear weapons and their components.

The DOE/NNSA Render Safe program supports the following activities:

- *Device Stabilization* – The Stabilization Operations program is a joint effort of the FBI and DOE/NNSA.
- *Device Disablement* – The Joint Technical Operation Team and ARG provide technical expertise from the DOE/NNSA nuclear weapons design and engineering laboratories. They provide assessments based on nuclear design principles and advise on the use of device disablement tools and techniques.
- *Device Characterization and Packaging* – DOE/NNSA deploys specialized teams to determine the nature of a nuclear/radiological threat device using advanced diagnostic techniques and secure device packaging for transportation to a disposition location.
- *Device Secure Packaging & Transportation* – The DOE/NNSA Office of Secure Transportation handles the transportation of a nuclear weapon.

Nuclear Forensics

Under the NCTIR Program, CTCP's Office of Nuclear Forensics is the Department's lead for pre-detonation nuclear device forensics operations as well as interagency technical and operational support to material and post-detonation technical nuclear forensics. The DOE/NNSA technical nuclear forensics operations teams have specialized personnel, equipment, and capabilities to support the technical nuclear forensics mission. When those DOE/NNSA-developed capabilities are needed, the FBI (as the U.S. federal agency responsible for the investigation of crimes involving WMD within the United States and its territories) has designated the FBI Laboratory as its lead for coordinating technical nuclear forensics for the United States in incidents involving an IND, RDD, or interdicted nuclear or radiological material.

Given the crosscutting nature of nuclear forensics, a number of organizations within the Department make important contributions in this area:

- The CTCP Office of Nuclear Forensics maintains the operational capability for pre-detonation device disassembly and forensic examination, provides operational support for forensic response to post-detonation events, and coordinates the forensic analysis of SNM. To carry out these missions, CTCP maintains a readiness posture to deploy ground sample-collection teams, deploy device disposition and assessment teams, and conduct laboratory operations in support of bulk nuclear material and post-detonation forensics.

- The DNN R&D program conducts research to improve the U.S. technical nuclear forensic capability. This research is focused on technical areas in which limitations or uncertainties in current techniques exist, as well as areas where emerging technologies may revolutionize nuclear forensic methods. DNN R&D's work in this area supports and is augmented by the IND assessment activities of the CTCP Office of Nuclear Threat Science.
- DNN's GMS program works to strengthen foreign partner nuclear forensic capabilities, which are integral to a robust program to deter and counter illicit nuclear smuggling and strengthen the security of nuclear and radiological material.
- DOE, in addition to the functions above, is responsible for maintaining the National Nuclear Forensic Library of the United States.

CTCP's Office of Nuclear Forensics is the Department's for providing the technical evaluation of nuclear materials and related items recovered out of regulatory control, with the goal of determining the history and origin of the material or items. The United States maintains effective and robust forensics and attribution capabilities so that, should nuclear/radiological smuggling or an attack be attempted or take place, appropriate actions can be taken and the responsible parties identified.

Within the pre-detonation device mission, following render safe, DOE/NNSA supports the disassembly and technical assessments of the IND or RDD and supports the FBI in collection of traditional forensic evidence. To provide this support, DOE/NNSA forms the Disposition and Forensic Evidence Analysis Team (DFEAT), a deployable team with specialized equipment and expertise in weapons engineering, explosives handling, arming and firing, detonators, explosives, device design, and other specialties.

Within the post-detonation debris mission, the DOE Forensics Operation (DFO) team forms as part of an interagency Ground Collection Task Force with the FBI and DOD. The DFO is a deployable, specialized response team composed of subject matter experts from across the DOE national laboratory complex. This team provides a reliable capability to support ground sample collection, perform in-field sample processing, and deliver high quality samples to the FBI for shipment to designated laboratories for analysis. DOE/NNSA also supports evaluation of analytical results and supports proficiency and readiness for device reconstruction, the interpretation of data following collections, and analysis of debris.

DOE/NNSA also coordinates the interagency Bulk Special Nuclear Material Analysis Program (BSAP), capable of delivering high accuracy measurements of nuclear materials. Measurement capability is sustained through proficiency testing on nuclear materials and benchmarking of analytical methods, integrating with signature development for assessing the production history and origin of materials.

Nuclear Forensics Priorities

- Improve the ability to generate quick technical device assessments and integrate into the larger U.S. attribution effort.
- Document, exercise, and improve technical capabilities for pre- and post-detonation nuclear forensics.
- Conduct infrastructure improvements at the NNSS to ensure a safe, effective, sustainable facility for disposition operations.
- Improve technical capabilities to collect and screen debris in the field.
- Validate and benchmark radio chronometry, trace element, and morphology methods.

Nuclear Forensics Performance Metrics

- Maintain the capability to respond to pre-detonation INDs.
- Maintain the capability to respond to post-detonation INDs.
- Maintain laboratory staff expertise, capability, and readiness to respond and analyze pre-detonation nuclear material

Disposition and Device Assessment

The technical and operational proficiency of the DFEAT to respond, to disassemble, and perform device assessment on INDs has improved greatly in the last few years. The DFEAT composition, depth, and training have been tuned to ensure effectiveness and responsiveness. Facility and communication improvements at NNSS have improved the ability to respond. Interagency teamwork and integration and DOE technical proficiency at the nuclear weapons laboratories, NNSS, and Pantex sites have greatly improved the ability to perform device assessment and support FBI traditional forensics.

Ground Collections

The DFO team has improved technical and operational capabilities to respond, plan collection missions, and screen nuclear debris following a detonation as part of the interagency Ground Collections Task Force. DFO teams continuously stand ready to deploy within eight hours of a notification. DFO continues to improve staff proficiency and develop cutting-edge methods to collect and screen nuclear debris in the field to ensure sample quality.

Bulk Special Nuclear Material Analysis

A bulk SNM analysis capability for nuclear forensics was conceived in 2011 and reached operational status in FY 2013 through interagency teamwork and integration of DOE technical proficiencies at the nuclear weapons laboratories. Operational procedures are complete and the program continues to validate a number of methods specific for attribution. Capability is maintained through proficiency testing on nuclear materials and benchmarking of analytical methods.

FY 2017 Accomplishments

- Supported and participated in FBI-led domestic and DOD-led OCONUS render safe exercises that approximated the complexity of conducting operations on a nuclear/radiological device or damaged U.S. nuclear weapon in the United States.
- Supported and participated in continuous activities, including render safe exercises and technical drills that approximated the complexity of conducting operations on damaged U.S. nuclear weapons in the United States.
- Conducted a capability challenge event with international partners focused on a render safe event, during which DOE/NNSA works with select countries to conduct technical diagnostics on a simulated IND in a secure environment.
- Conducted four Navy Explosive Ordnance Disablement Basic Courses for the Navy.
- Conducted Block I through VIII training courses (64 one-week courses in total) for DOD and the FBI.
- Conducted 15 Advanced Technical Operations I and II courses for a DOD mission support partner.
- Sustained training and equipment maintenance for Stabilization Teams in ten cities and completed the stand-up of a fully operational Stabilization Team in an eleventh city.

- Conducted five TRNSO exercises with the FBI response teams.
- Provided technical assistance and support to federal, state, tribal, and local government agencies to deal with incidents, including addressing terrorist threats that involve potential use of nuclear devices and WUNM.
- Provided technical assistance to a lead federal agency to search for or detect illicit nuclear or radiological material.
- Continued collection and expert analysis of radiological material signatures through the DOE Radiological Triage Program.
- Continued rollout of the robust classified communications system in conjunction with mission partners and sustain data communications systems between the field teams and home teams.
- Maintained training for the search, consequence management, and render safe response teams and home teams.
- NNSA emergency response teams responded to four real-world incidents, providing; (1) radiological technical expertise to a criminal investigation; (2) radiological monitoring involving the accidental release of radiological material, facilitating response and recovery, and medical assessment and advice in the treatment of individuals exposed; (3) radiological monitoring and classified stockpile weapon component identification in support of the US Navy; and (4) training, specialized tool fabrication, and technical reach-back to deployed DOD teams in support of radiological material verification operations .
- NNSA participated in six national level exercises, serving as the lead for one in coordination with its mission partners, DOD, DHS, and DOJ/FBI. In addition, the NNSA Radiation Emergency Assistance Center/Training Site (REAC/TS) responded to 40 calls for assistance for the medical management of personnel potentially exposed to excessive doses of ionizing radiation.
- Began to recapitalize critical emergency response equipment that has passed beyond its planned life cycle.
- Provided technical and operational capabilities in support of the U.S. Government interagency National Technical Nuclear Forensics program.
- Maintained readiness to respond to pre- and post- detonation nuclear events and improve technical capabilities to collect and screen post-detonation debris in the field.
- Participated in two Nuclear Forensics Ground Collection Task Force field exercises and one training event.
- Fully supported post-detonation device reconstruction training and exercises.
- Conducted two nuclear forensics pre-detonation device DFEAT exercises.
- Established nuclear forensics capability to handle SNM and pits at Los Alamos National Laboratory, and continued the laboratory’s PF4 plans and procedure development in support of the Nuclear Forensics Pre-Detonation Device mission.
- Continued preventative and corrective facility maintenance at NNSS’s P-Tunnel, for support to the pre-detonation device program. Addressed broader infrastructure improvements at the NNSS.
- Maintained an operational capability for BSAP.

- Led U.S. support to the U.S./UK Joint Working Group 29 Nuclear Forensics User Group and continued associated technical work exchanges.

Program Challenges

- Transitioning the Post-Detonation Device assessment competency from a research and development focus to an operational capability.
- Replacing infrastructure at the Nuclear Response Group Readiness Operations Complex to improve safety, effectiveness, and sustainability for deployment, equipment maintenance, and storage.
- Developing, training, and maintaining a cadre of individuals with expertise in the areas necessary to support emergency response operations.
- Operating under repeated fiscal year continuing resolutions increases the challenges in the acquisition, training, and implementation of a highly secure communications capability required to support the successful disablement of a potential WMD. The mobile communications platform is already employed by DOE mission partners in the DOD and the FBI and will allow seamless communications among the DOD/FBI operational team at an incident site, DOE/NNSA scientific technical reachback experts, law enforcement, and the Intelligence Community. Deployment of this mobile communications platform began in FY 2016 to the highest priority nuclear incident response teams, but additional equipment and personnel depth are needed to ensure a robust capability to transmit essential classified technical data during a crisis.
- Replacing or improving nuclear emergency response equipment that has exceeded its planned service life. Repeated delays of equipment recapitalization in lieu of training and maintenance of existing equipment has resulted in a large backlog of required procurements to ensure our national response readiness. These include high resolution spectroscopic identification systems (for nuclear/radiological material search/detection), the next generation of the neutron multiplicity detector (to characterize fissile materials), and the health physics kits required for responders to properly protect themselves in the event of a radiological emergency.

4.2 Consequence Management

4.2.1 Program Strategy, Priorities, and Performance Metrics

The Consequence Management program provides preeminent, national-level technical expertise during the initial hours and days following a nuclear or radiological event through the evaluation of the radiological consequences of a nuclear or radiological incident. The program organizes the delivery of this essential response capability for mission integration with other federal, tribal, state, local, and international radiological consequence assessment capabilities and for full integration within the incident management structure and organization.

Program objectives include the following:

- Develop and maintain a cadre of individuals with expertise in the areas of radiological data collection, assessment, and interpretation.
- Establish and maintain equipment, tools, facilities, and methodologies to support the mission.
- Organize and integrate the radiological hazard consequence assessment capabilities to effectively support key leaders and incident management.

- Continue to work with international partners to strengthen the global nuclear emergency management system.

4.2.2 FY 2017 Program Activities, Accomplishments, and Challenges

Emergency Response

In the event of a nuclear or radiological emergency, DOE/NNSA engages an emergency response management system to assist first responders, and consequence management systems to plan and manage nuclear/radiological incident responses and mitigation efforts. This DOE/NNSA-supported response architecture includes management of the multiagency Federal Radiological Monitoring Assessment Center, which coordinates on-scene monitoring and assessments during a radiological emergency; a Radiation Emergency Assistance Center, providing 24-hour consultation services on radiation-affected health problems; an Aerial Measurement System, in which DOE/NNSA aviation-based equipment conducts wide-area radiological searches and surveys for emergency planning and response management; and the National Atmospheric Release Advisory Center (NA RAC), which provides real-time predictions of atmospheric transport of radioactivity from a nuclear/radiological incident.

Figure 19. National Atmospheric Release Advisory Center (Lawrence Livermore National Laboratory, CA)

FY 2017 Accomplishments

- Served as a lead U.S. federal agency for a National Level Exercise.
- Coordinated with EPA, NRC, other elements within DOE, and provide support to the Nuclear Emergency Support Team programs to safeguard the public and environment to ensure the successful resolution of an accident or incident.
- Facilitated radiological response and recovery efforts in the event of the intentional or accidental release of nuclear or radiological material.
- Informed public health officials on evacuation guidance and health effects from the accidental or intentional release of radiological materials.

International Cooperation

Enhancing foreign preparedness and the necessary capabilities to respond to nuclear and radiological incident, accidents, and terror events fulfills key national and international security objectives for the prompt, effective, and coordinated response to nuclear and radiological incidents at their origin. Recognizing the global impacts of a nuclear or radiological terrorist act, or nuclear accident, CTCP leverages the DOE/NNSA emergency response capabilities for U.S. domestic incidents to pursue strategic engagements with key foreign governments and international organizations to reduce the risk and consequences of nuclear and radiological incidents internationally.

DOE/NNSA currently cooperates with more than 80 countries and 10 international organizations. It has hosted international search and consequence management workshops in many countries.

DOE/NNSA liaises with, and participates in, projects sponsored by international organizations, including the IAEA, Nuclear Energy Agency, the European Union, the North Atlantic Treaty Organization (NATO), the Group of Seven (G7) countries, World Health Organization, World Meteorological Organization, and the Arctic Council. The IAEA's Incident and Emergency Center maintains the Response and Assistance Network, which is one mechanism for coordinating international assistance.

DOE/NNSA assists partners by providing capabilities for atmospheric modeling, radiation characterization and mapping, and data analysis for radiation monitoring and assessments.

These capabilities include:

- Predictive modeling to provide an estimate of dispersion of radioactive material for the purposes of decision-making associated with protective actions to protect the public, siting of response capabilities, and informing the planning of monitoring activities. Modeling may include projections of future possible release scenarios.
- Aerial, ground-based, and mobile radiation monitoring and characterization (soil, water, air, and vegetation) to define the amount and extent of contamination; inform decision making and response actions; and evaluate the hazards to the responders, environment, and public.
- Radiation data mapping technologies to support incident preparedness and response actions.
- Timely reach-back and laboratory analysis to evaluate the amount and type of radioactive materials and inform first responder priorities and public protective actions.
- Medical response to provide technical assistance on the treatment of radiological injuries and contaminated patients, and training for a cadre of medical personnel to respond to radiological injuries and contaminated patients.

CTCP's nuclear incident policy and cooperation efforts also provide operational training in key incident response areas such as: radiological search, secure, and recovery; operational nuclear/radiological mission planning; and radiation security and response preparedness for major public events. DOE/NNSA leverages the knowledge, skills, and capabilities in medical response that reside within the DOE/NNSA nuclear security complex to assist foreign partners. DOE/NNSA conducts the International Medical Radiological Response Countermeasures training course for hospital management, doctors, nurses, and other medical professionals to stress the integration of professional medical care and radiation protection/health physics principles. DOE/NNSA conducts the International Radiological Assistance Program Training for Emergency Response to provide specialized nuclear/radiological emergency preparedness and response training, based on training developed for U.S. responders. DOE/NNSA reaches a broader international audience by conducting several specialized, multilateral training courses per year with the IAEA and three per year with NATO.

FY 2017 Accomplishments

- Revised and updated capacity-building training modules/efforts.
- Held a Technical Exchange Forum on Emerging Nuclear/Radiological Incident Preparedness and Response issues with domestic and international operational responders.
- Initiated work with two new emergency preparedness and response foreign partners.

- Expanded IAEA engagement to bridge gaps in nuclear/radiological incident preparedness and response, especially in nuclear security event response.

Program Challenges

- Prioritizing engagement partners and opportunities while addressing sustainability requirements.

Enterprise Approach to Emergency Management

During the first quarter of FY 2017, the Department achieved an initial operational capability of its Unified Coordination Structure (UCS) and its enterprise-wide, all-hazards approach to emergency management. The Department's enterprise-wide approach to emergency management includes two major institutional mechanisms: the Emergency Incident Management Council (EIMC) and the UCS, with its associated Unified Coordination Group, Command Staff, and General Staff. The Office of Emergency Operations is the lead governance organization over the Department's Emergency Management Enterprise and it plays a key role in supporting both the EIMC and the UCS.

The EIMC, established by the Secretary of Energy in FY 2015, is responsible for addressing strategic-level aspects of emergency management across the all-hazards spectrum. Specifically, it directs the establishment of specialized working groups to improve the Department's overall emergency management posture, increases preparedness through training and exercises, develops policy and

Deepwater Horizon Oil Spill
(April 2010)

Fukushima Earthquake and Tsunami
(March 2011)

Hurricane Sandy
(October 2012)

Waste Isolation Pilot Plant Truck Fire and Radioactive Release
(February 2014)

Figure 20. Examples of All-Hazard Emergency Response Events

planning, and oversees the completion of corrective actions. This approach has as its foundation a UCS directed by departmental leadership through the EIMC and is informed by common standards and procedures for emergency preparedness and response. This maturing enterprise approach to emergency management improves centralized coordination of the Department's various emergency operations components during all-hazards emergencies. The Associate Administrator for Emergency Operations is leading this coordinated effort.

The EIMC will not manage or direct emergency operations or incidents, except where required by statutory authorities. Rather, in the event of an emergency requiring a department-wide coordinated response at the operational level, the EIMC will authorize stand-up of the UCS for this purpose. The UCS will be composed of representatives from relevant DOE and DOE/NNSA program offices and will provide tactical-level support to the Department's incident commanders and deployed response assets during emergency operations. It will also provide situational awareness-focused reporting to the EIMC. The UCS is organized based on the National Incident Management System—an organizational system that all federal departments and agencies are required to adopt. The UCS became operational during the third quarter of 2016 and was formally assessed to be at Initial Operational Capacity in the first quarter of FY 2017.

The Department's all-hazards emergency response capabilities, including CTCP's nuclear and radiological teams and assets, are elements of the Department's Emergency Management Enterprise. The Department's Emergency Management Enterprise is closely coordinated with federal, state, tribal, and local agencies. This coordination is guided by interagency directives, including PPD-8. This directive requires the development of National Planning Frameworks, which set national strategy and doctrine for emergency preparedness, as well as Federal Interagency Operational Plans, which integrate and synchronize capabilities across federal agencies. The Department's Emergency Management Enterprise is undergoing a series of process improvements that will culminate in the achievement of an enterprise-wide, all-hazards full operational capability at the end of the first quarter of FY 2020.

Office of Emergency Operations

The Office of Emergency Operations is the Department's emergency management lead office, pursuant to DOE Order 151.1D. In this role, it provides necessary governance and operational support to the Emergency Management Enterprise and ensures the full engagement, coordination, and involvement of the all-hazards emergency management community in this ongoing emergency preparedness improvement effort. Emergency preparedness includes the ability to manage and coordinate the Department's response to all-hazards emergencies, such as natural disasters**,** biological disease emergencies **and** man-made or technological hazards impacting DOE/NNSA laboratories, plants, and sites.

The Office of Emergency Operations provides the training, exercises, policies, procedures, and infrastructure that enable CTCP and other DOE and NNSA program staff to effectively carry out their emergency management and response duties. The responsibility of the Office of Emergency Operations also includes planning and program management related to the DOE/NNSA Continuity Program and associated COOP and COG activities that ensure our Primary Mission Essential Functions are maintained through any crisis event.

The mission objectives of the Office of the Associate Administrator for Emergency Operations are to:

- Ensure that capabilities are in place to respond to any NNSA or DOE facility emergency and promote the consistency of emergency management practices at all sites.
- Manage the Department's stand-up and maturation of a complex- wide all hazards Emergency Management Enterprise.

- Ensure implementation of actions and deliverables identified by the Defense Nuclear Facilities Safety Board Recommendation 2014-1, *Emergency Preparedness and Response*.
- Provide technical support to DOE/NNSA sites and facilities in the implementation of revised DOE Order 151.1D, *Comprehensive Emergency Management System*.
- Align the Emergency Management Enterprise with the DOE UCS, and with its Unified Coordination Group, Command Staff, and General Staff.
- Provide a single integrated common operating picture of situational awareness on a near real-time basis.
- Manage the Department's Emergency Operations Center, including its continuous Watch teams, and its alert and warning system.
- Manage the development, maintenance, and implementation of continuity programs for the Department.

Subordinate Offices to the Associate Administrator for Emergency Operations

Plans and Policy: This office develops and issues all DOE and NNSA emergency management policy and strategic plans; oversees the Comprehensive Emergency Management System implementation for DOE and NNSA sites, facilities, and transportation activities; develops and issues directives, technical guides, technical standards, procedures, and protocols for emergency management planning, preparedness, training, exercise, readiness assurance, recovery, and response; and provides technical assistance to DOE and NNSA sites for emergency planning, information exchange, and continuous improvements in emergency management. The office also develops and synchronizes Criteria Review and Approach Documents, and is responsible for developing, managing, and maintaining Enterprise Emergency Plans and corresponding implementation procedures. In coordination with the Office of Preparedness, this office assesses and validates the effectiveness of DOE and NNSA's emergency management policies, plans, capabilities, contractor performance, and training. It also coordinates the development of corrective action plans, including status, validation, and verification of corrective actions; tracks and reports readiness metrics; and initiates and tracks best practices and areas to improve preparedness and operational performance of emergency management and response.

Preparedness: This office develops a comprehensive National Incident Management System-compliant training and education program for emergency management stakeholders and develops training events for Headquarters personnel. It also develops emergency management guidance, including resource levels, program priorities, requirements, standards**,** milestones, and reporting. Finally, the office issues requirements for emergency management training activities and assists staff at DOE/NNSA site offices in meeting emergency management readiness requirements.

Operations and Exercises: This office prepares for and supports an integrated enterprise-wide command structure for DOE to manage and synchronize all-hazards emergencies from response through recovery. During an emergency, it executes a National Incident Management System-informed UCS and Crisis Action Teams as necessary to address specific response requirements including continuity programs. The office also manages all preparedness functions for the Nuclear Incident Team and Current/Future Operations sections, including planning, monitoring, concept of operations, procedures, and protocols and coordinates with the Office of Preparedness on training, exercises, and evaluations. This office chairs the Enterprise Exercise Working Group and leads the Department's efforts in U.S. interagency exercise planning and coordination to provide consolidated requirements inputs to National Level Exercises. In addition, the office develops a comprehensive Homeland Security Exercise and Evaluation Program-compliant exercise program; tracks, plans, and executes DOE and NNSA emergency response capabilities, including senior leaders in DOE and NNSA enterprise-wide exercises and National Level Exercises; and participates in the National Security Council's Domestic Resiliency Group's Exercise and Counterterrorism and Security Group's exercise efforts and the National Security Council's Exercise and Evaluation interagency coordination group.

Consolidated Emergency Operations Center: This office serves as the Department's 24/7/365 single point of contact for all departmental and interagency notifications regarding situations requiring centralized management. The office is responsible for the operation, communications, and infrastructure of several coordination, control, and communications nodes supporting DOE Headquarters in Washington, DC. These nodes included the Alternate Operations Center and the DOE Liaison Desk at DHS. Additionally, the office provides communication and/or infrastructure support to several other critical DOE response nodes: the Continuity of Operations area, alternate DOE Senior Leadership Facilities at Mount Weather, and the DOE devolution location in Albuquerque, NM. As the single point of contact, this office provides vital capabilities for coordinating DOE/NNSA's role in the national response to events such as major emergencies, heightened international tension, natural disasters, and acts of terrorism. On a daily basis, the office leverages its strong working relationship with multiple stakeholders across the DOE enterprise; with the DOE/NNSA nuclear security enterprise of laboratories, plants, and sites; and with the U.S. interagency to maintain a department-wide common operating picture. The office manages the Emergency Communications Network (ECN) to provide secure and non-secure voice, video, and data information for departmental emergency response and national asset support in coordination with the Office of Counterterrorism and Counterproliferation, and manages the infrastructure necessary for effective DOE/NNSA continuity programs (i.e., alternate and devolution facilities and redundant communications architecture).

Figure 21. Emergency Operations Center, Forrestal Building (Washington, DC)

FY 2017 Accomplishments

- Managed and coordinated the efforts of the Department as it validated that the UCS met the established requirements for initial operational capability of the Emergency Management Enterprise.
- Developed the UCS Concept of Operations Plan and associated standard operation procedures that facilitated the UCS Initial Operational Capability.
- Organized and lead a department-wide Emergency Management Enterprise Exercise Working Group to coordinate and synchronize the Department's five-year Emergency Management Enterprise Exercise Plan that improved the coordination and unity of effort of all-hazards exercise activities throughout the Department.
- Provided dedicated continuity communications capabilities to the DOE/NNSA essential emergency operations functions, including the Mobile Response and Emergency Operations Center/Watch Office.

- Developed and maintained the Emergency Management Enterprise's Knowledge Management System.
- Revitalized the Office of Emergency Management's Readiness Assurance Program to provide timely and focused technical support to the Department's Comprehensive Emergency Management System.
- Developed a complex-wide Threat and Hazard Identification and Risk Assessment processes in accordance with the National Preparedness Goal and provide training and technical assistance to DOE sites and facilities in meeting this requirement.
- Drafted the Emergency Management Enterprise training policy and instituted the development of an emergency management training curriculum in support of all-hazards emergency operations.
- Identified specific Emergency Management Enterprise training needs based on job/task or function responsibilities.
- Developed and piloted the Emergency Management Criteria Review and Approach Document.
- Implemented enhanced emergent departmental and national level continuity policy and associated requirements.
- Evaluated network operations and implemented administrative and operational improvements to effectively satisfy all cybersecurity; Capital Planning & Investment Control (CPIC); and other administrative, documentary, and operational requirements using recognized best practices.
- Completed network improvements to fully satisfy the DOE/NNSA national security mission requirements for complied federal cybersecurity standards and information technology reporting requirements. Chartered and administered the Emergency Management Advisory Committee (EMAC) as an inclusive forum for Federal program, field and site office managers to facilitate timely resolution of emergency management issues.

Program Challenges

- Complex wide coordination and synchronization of policy requirements as the Administration promulgates new goals and objectives, which could impact the timely development and implementation of emergency management guidance.
- Training and skills development for preparedness personnel to facilitate Emergency Management Enterprise training programs.

4.3 FY 2018 Future Years Program Plan

For FY 2018, DOE/NNSA will engage its emergency response program in the following activities.

Main Areas of Program Activity for FY 2018

- Manage and coordinate FY 2018–FY 2020 efforts across the Department to demonstrate and validate that the Emergency Management UCS has met the established requirements for Full Operational Capability, planned to occur in early FY 2021.
- Develop, train, and retain world-class emergency management professionals and experts from across the Department to serve in the UCS.

- Ensure that the Emergency Management Enterprise has a persistent capability to respond to and manage an all-hazards incident, emergency, or event in support of a lead federal agency.
- Continue to develop and/or hire training specialists.
- Synchronize department-wide participation and execution of full-scale, complex facility exercises to ensure emergency response preparedness and synchronization.
- Facilitate and lead robust participation in maturing the Department's Independent Emergency Management Oversight Program.
- Facilitate and lead comprehensive coordination and synchronization of the emergency management-focused Corrective Action System, the Integrated Safety Management System, and the Lessons Learned System to mature and sustain a DOE risk-based approach to emergency management.
- Facilitate job/task/function analyses to identify specific training needs.
- Provide complex-wide access to the Emergency Management Knowledge Management System and also train emergency management personnel to use the system.
- Continue to provide dedicated continuity communications capabilities to the DOE/NNSA essential emergency operations functions (Mobile Response, Emergency Operations Center/Watch Office) and National Response Framework via an available, compliant, confidential, effective, secure, protected, and resilient network.
- Continue network improvements to fully satisfy the DOE/NNSA national security mission requirements, comply with federal cybersecurity standards and information technology reporting requirements, and support the NNSA Network Vision.
- Maintain and improve the use of the NNSA Office of the Chief Information Officer-mandated Information Assurance Response Center infrastructure for monitoring of the ECN.
- Sustain ECN infrastructure through effective and innovative real estate management, telecommunications strategies, and hardware/software service strategies.
- Early adoption and implementation of the CPIC Implementation Factor 7 – Data Center Management in harmony with the Federal Data Center Consolidation Initiative.

Chapter 5: Crosscutting Capabilities

5.1 The Role of the DOE Scientific Complex and NNSA Nuclear Security Enterprise

The DOE complex of national laboratories, plants, and sites is central to DOE/NNSA's ability to prevent proliferation and nuclear terrorism. The DOE complex provides the science, technology, engineering, and manufacturing capabilities that are the tools by which DOE/NNSA solves the technical challenges of combating nuclear terrorism and proliferation, verifying treaty compliance, and guarding against threats posed by nuclear technological surprise. All parts of the DOE scientific enterprise contribute to the DOE/NNSA nonproliferation and counterterrorism mission. Additionally, the national laboratories, plants, and sites of the NNSA nuclear security enterprise have unique and extensive science, technology, engineering, and manufacturing capabilities developed over decades of nuclear weapons research, development, design, engineering, production, and stockpile management, which enables the DOE complex to play a critical role in the nation's ability to understand nuclear proliferation and terrorism threats worldwide. The elements of the NNSA nuclear security enterprise are also U.S. national assets, contributing directly to the missions of DOD, DOJ, DOS, DHS, the U.S. Intelligence Community, and other agencies and government entities. The enterprise also supports broader international efforts through

Figure 22. National Laboratories, Plants, and Sites Contributing to the DOE/NNSA Nuclear Threat Reduction Mission

Mutual Defense Agreements and agreements with other countries as part of the collective goal to ensure nuclear deterrence and reduce the threat of nuclear terrorism.

As described in NNSA's *Enterprise Strategic Vision*, each of the organization's three mission pillars are supported by the three specific crosscutting activities:

- Advancing science, technology, and engineering;
- Supporting its people and modernizing its infrastructure; and
- Developing a management culture that promotes a safe and secure nuclear enterprise.

DOE/NNSA is strongly committed to maintaining robust capabilities across all three crosscutting activities and to effectively managing and overcoming challenges in each area. To achieve this, DOE/NNSA undertakes a number of specialized initiatives, including both enterprise-wide initiatives and some that are specific to the nuclear and radiological threat reduction programs.

5.2 Science, Technology, and Engineering

5.2.1 Overview of Science, Technology, and Engineering Capabilities

The science, technology, and engineering (ST&E) capabilities that reside across the nuclear security enterprise and the greater DOE complex are leveraged to perform the research and development required to address the challenges and potential consequences of nuclear and radiological proliferation and terrorism. This research and development advances U.S. capabilities to secure nuclear materials, prevent proliferation, detect nuclear detonations, verify treaties, and interdict smuggled nuclear materials in support of the NTR pillar. The deep technical knowledge of the DOE/NNSA laboratories, plants, and sites regarding nuclear weapon design, engineering, and materials underpins the research and development related to characterization and forensics abilities, and prepares the United States to respond to nuclear or radiological accidents or incidents anywhere in the world. Information gained from decades of U.S. nuclear weapon research is combined with newer experimental data to model IND designs and improve confidence in global monitoring of low-yield underground explosions.

Specifically, some of the key technical disciplines supporting the DOE/NNSA NTR mission are shown in the following table.

Table 1. Key ST&E Disciplines of Nuclear Threat Reduction Mission

• Nuclear Reactor-related Expertise (including Reactor Design and Engineering, Safety Systems, Reactor Material Science, Fuel Design and Engineering) • Nuclear Material Science and Material Processing • Nuclear Fuel Cycle Design and Engineering • Chemical and Radiochemical Engineering • Accelerator Physics • Advanced Manufacturing • Computational Sciences and Engineering	• Radioactive Material Package Design, Testing, Licensing, Training, and Safety Basis • Neutronics Analysis and Simulation • Explosive Detection Expertise (Seismology, Infrasound, Hydroacoustic Expertise) • Radiation-focused Sciences (including Radiography, Radiation Characterization, Detector Physics and Designs, Diagnostic System Design and Operations Training, Dose Assessment and Health Implications)	• Spectroscopy • Systems Development and Testing • Nuclear Weapon Design and Engineering • Non-nuclear Sciences (Aerospace, Chemistry, Biology, Industrial Engineering, Mechanical Engineering)

The DOE and NNSA Management and Operations (M&O) partners (guided by the mission requirements communicated from DOE/NNSA federal program managers) determine the appropriate mix of ST&E skills needed to execute and support the nuclear threat reduction mission. DOE and NNSA Headquarters work jointly with M&O partners to determine the optimal management strategies for balancing S&TE needs across the entire DOE/NNSA mission space, including the nuclear threat reduction pillar.

5.3 Key ST&E Challenges and Responses

5.3.1 Sustaining Key ST&E Competencies

In addition to directing and funding specific projects to be carried out across the complex, DOE/NNSA is also responsible for sustaining these broader ST&E capabilities over the long term and for ensuring that competencies evolve as needed in response to emerging requirements. Balancing this long-term stewardship role with the near-term requirement to execute particular projects and programs can be challenging. DOE/NNSA has adopted a number of measures to meet this challenge.

First, in recognition of the importance of the long-term health of the laboratories, plants, and sites, the U.S. Congress has authorized and encouraged them to devote a relatively small portion of their research effort to creative and innovative work that serves to maintain and develop scientific and engineering capabilities in areas of strategic importance to the nation. This effort is known as Lab and Plant Directed Research and Development.

DOE/NNSA supports Laboratory and Plant Directed Research and Development projects across the nuclear security enterprise, including in the area of nuclear threat reduction. Laboratory and Plant Directed Research and Development investments throughout the DOE national laboratory complex are considered by DOE/NNSA NTR programs in the development of technical roadmaps. They also provide insight into the strategic priorities of the national laboratories themselves, as well as opportunities for the United States to leverage these investments in support of a variety of national security objectives.

Second, the DOE/NNSA Strategic Partnership Projects process enables other government agencies to fund projects related to global nuclear threat reduction. Through the Strategic Partnership Projects, DOE/NNSA provides outside organizations like DOD, DHS, and DOS with access to the nuclear security enterprise facilities and expertise on a reimbursable basis. These projects serve an important role in maintaining and growing the core ST&E competencies within the enterprise.

Third, in 2016 DOE/NNSA instituted a new, enterprise-wide laboratory strategic planning process in which laboratory directors meet annually with the NNSA Principal Deputy Administrator to discuss their laboratory's strategic plans, including their plans for sustaining and growing key ST&E competencies. This process, modeled on a similar and successful practice by the DOE Office of Science, helps ensure high-level DOE/NNSA engagement on the long-term issues facing the laboratories, plants, and sites, including in the area of ST&E.

Examples of Laboratory and Plant Directed Research and Development and Strategic Partnership Projects That Advance Nuclear and Radiological Threat Reduction

Lab and Plant Directed Research and Development and Strategic Partnership Projects are both critical for the long-term sustainment and growth of the science, technology, and engineering capabilities at laboratories, plants, and sites. These projects also deliver important benefits for the nuclear and radiological threat reduction mission.

For example, **Brookhaven National Laboratory (BNL)** in Upton, NY, used Laboratory Directed Research and Development funds to support improvements to radiation detection technology. BNL has funded research in techniques to reduce the effect of impurities and boundaries in existing detector materials and extend the lifetimes of the detectors. BNL is also investigating new materials that could improve detector performance.

Another example is at **Oak Ridge National Laboratory (ORNL)**, where a Strategic Partnership Project with the **Nuclear Regulatory Commission** has supported the development and maintenance of the SCALE code system, a key computational tool used to analyze reactors and characterize spent fuel isotopic distributions. The SCALE toolset and the ORNL staff experience developed through the work has supported development of measurement techniques for nuclear safeguards applications.

5.3.2 Coordinating with Other U.S. Government Agencies and Academia

In addition to sustaining and growing the capabilities resident at DOE/NNSA's laboratories, plants, and sites, coordination on ST&E issues with other government agencies and academia is also essential. With regards to ST&E for nuclear and radiological threat reduction, DOE/NNSA achieves this coordination through a number of mechanisms.

First, DOE/NNSA coordinates closely with leading universities on ST&E activities, especially through the University Consortia program. This program, which is sponsored by DNN R&D (and is part of the congressionally-directed IUP), is composed of three consortia that link universities and DOE national laboratories. These consortia provide an effective conduit for integration of basic academic and applied national laboratory research. They also provide basic research in concepts, technologies, and paradigms that is complementary to lab research and required for meeting the nuclear and radiological threat reduction mission.

DOE/NNSA also partners with universities through other channels to support ST&E in the nuclear and radiological threat reduction area. For example, Pacific Northwest National Laboratory has partnered with Washington State University for the past seven years to develop new instruments, tools, and methods used in nonproliferation and international safeguards activities.

Figure 23. PNNL Engineer Working with a Washington State University Student

Second, in addition to coordination with academia, DOE/NNSA also coordinates closely with other agencies in the U.S. Government on ST&E efforts related to nuclear and radiological threat reduction. For example, DNN R&D establishes its program priorities based on U.S. strategic goals, policy guidance, legal and treaty obligations, and other commitments (e.g., those to the U.S. Nuclear Detonation Detection System). Technology maturation often must occur in advance of formal requirements, so DNN R&D engages mission stakeholders in developing long-term, comprehensive research prioritization and investment strategies. DNN R&D also takes into account external views as reflected in the Nuclear Defense Research and Development Roadmap and the 2014 Defense Science Board Task Force Report on Nuclear Treaty Monitoring and Verification Technologies, as well as broad interagency perspectives to form, prioritize, and implement research investment strategies across the interagency.

Another important mechanism for interagency coordination on ST&E activities are the national comprehensive research and development test beds, which DOE/NNSA developed in coordination, or in partnership, with DOS and DOD and members of the U.S. Intelligence Community. Six such test beds have been established for the spiral development of tools and techniques for verifying and monitoring nuclear warhead reductions, detecting nuclear weapons proliferation and nuclear explosions, and advancing nuclear forensics.

5.4 Physical Infrastructure

5.4.1 Current Status

DOE/NNSA's NTR programs rely on a robust infrastructure of research laboratories, experimental facilities, test beds, high-performance computing, and material disposal facilities. Many of these assets are part of DOE/NNSA's nuclear security enterprise and are owned and primarily funded by NNSA. But some assets are located in sites operated by other DOE offices, including the Offices of Science, Nuclear Energy, and Environmental Management.

As described in detail in the *FY 2018 Stockpile Stewardship and Management Plan (SSMP)* and the forthcoming NNSA *Master Asset Plan (MAP)*, NNSA's physical infrastructure is funded and managed in two categories: General Purpose Infrastructure and Programmatic Infrastructure. General Purpose Infrastructure includes all of the facilities, infrastructure (such as roads and fire suppression systems), site utilities, and equipment that are not specifically program focused but are required to support mission execution. Programmatic Infrastructure includes the equipment, core capabilities, and processes housed and enabled by the General Purpose Infrastructure. Programmatic Infrastructure allows NNSA to carry out research, testing, production, sustainment, and disposition related to the entire range of its national security commitments.

To facilitate effective asset management, DOE/NNSA's Office of Safety, Infrastructure, and Operations collects key information on each real property asset across the enterprise, including the core capabilities that each asset supports, the asset's importance to those capabilities, and the ease or difficulty of replacing the asset. This information is used to calculate a Mission Dependency Index for each asset, which is crucial for risk-informed decision-making.

This system makes it possible for the DOE/NNSA nuclear and radiological threat reduction programs to look across the entire enterprise and identify assets that support their missions. In many cases, assets that are critical to the NTR programs are leveraged by multiple users, resulting in the NTR programs taking up a relatively small fraction of the assets' capacity. Understanding the importance of such assets to DOE/NNSA's NTR mission can help improve infrastructure management decisions and program planning.

Examples of the most specialized and distinctive assets supporting the NTR mission include the following:

- Efforts to eliminate or minimize the amounts of WUNM in civilian use depend on the facilities at the Y-12 National Security Complex, Idaho National Laboratory, and Savannah River Site to securely store HEU and separated plutonium removed from foreign countries, as well as H-Canyon at the Savannah River Site and the TA-55 Plutonium Facility at Los Alamos National Laboratory to process material for ultimate disposition. The minimization effort also relies on facilities such as the Advanced Test Reactor and the Fuels and Applied Science Building at Idaho National Laboratory, as well as Building 208 at Argonne National Laboratory, in Argonne, IL, to develop new LEU fuel for converting HEU research reactors.
- Developing and strengthening capacity to implement nuclear safeguards relies on a wide variety of laboratory facilities, including the Hazardous Materials Management and Emergency Response (HAMMER) training facility at the Hanford Site near Richland, WA; the safeguards laboratory at Oak Ridge National Laboratory; and the Advanced Test Reactor and safeguards laboratory at Idaho National Laboratory. DOE/NNSA also supports a network of national laboratories that

provide analytical support for IAEA safeguards. This network includes specialized facilities at Lawrence Livermore, Los Alamos, Oak Ridge, Pacific Northwest, and Savannah River National Laboratories.

- Strengthening the layered security systems around nuclear and radiological materials depends on several unique facilities. The DOE National Training Center's Integrated Safety and Security Training and Evaluation Complex (located on Kirkland Air Force Base, Albuquerque, NM) and the HAMMER facility are used to train foreign partners on guard force performance testing best practices and the use of radiation detection equipment. Also, Pacific Northwest, Los Alamos, and Oak Ridge National Laboratories collectively host an important joint test bed for radiation portal monitors and physical security components. Additionally, training areas at the Y-12 National Security Complex and Sandia, Los Alamos, Oak Ridge, and Pacific Northwest National Laboratories are key for international training. Finally, the New Brunswick Laboratory in Argonne, IL, provides crucial training on how to develop and attest standards as well as how to improve destructive analysis laboratory techniques in order to make more accurate measurements.

Figure 24. Interdiction Testing and Integration Laboratory (Pacific Northwest National Laboratory, WA)

- To conduct the research and development work related to proliferation and nuclear detonation detection, DOE/NNSA relies on the supportive capabilities at a number of laboratories, plants, and sites that enable mission-relevant research and development activities. DOE/NNSA has also developed several integrated test beds at the Nevada National Security Site to perform field experiments that advance U.S. monitoring and verification capabilities.

- For deepening the scientific and technical knowledge of nuclear threat device concepts, DOE/NNSA makes use of the Neutron Science Center, the Dual-Axis Radiographic Hydrodynamic Test facility, gas guns, Ancho Canyon, and the Proton Radiography facility at Los Alamos National Laboratory; the Superblock, the Contained Firing Facility, the High Explosives Application Facility, and the gas guns at Lawrence Livermore National Laboratory; the Z-Facility and Thunder Range at Sandia National Laboratories; and the National Criticality Experiments Research Center, Joint Actinide Shock Physics Experiment Research (JASPER) gas gun, the Big Explosives Experimental Facility, and the Baker Compound at the Nevada National Security Site. Understanding nuclear threat device concepts also requires high-performance computing platforms to design predictive models concerning device performance and experimental facilities to refine and validate these models. Computer platforms and codes supporting these functions include those developed specifically for nuclear counterterrorism analysis as well as others developed for the Stockpile Stewardship Program (SSP).

- To support an effective response to a nuclear or radiological incident or emergency, DOE/NNSA relies on a diverse base of rapidly deployable assets, including specialized facilities, vehicles, and equipment. These assets include the Aerial Measuring Systems stationed at the Radiation Sensing

Laboratories at Joint Base Andrews (Washington, DC) and Nellis Air Force Base (Las Vegas, NV); the NARAC at Lawrence Livermore National Laboratory; and the Emergency Operations Centers located at several national laboratories. These infrastructure elements help ensure that the U.S. Government has dedicated resources capable of quickly responding to nuclear or radiological incidents worldwide, as well as the emergency management infrastructure required to coordinate the response effort.

Figure 25. The Z- Facility (Sandia National Laboratories, NM)

5.4.2 Key Infrastructure Challenges and Responses

Aging Nuclear Security Complex Infrastructure

As described in the forthcoming *MAP*, much of DOE/NNSA's infrastructure is old, obsolete, and in poor condition. DOE/NNSA NTR programs face particularly acute challenges in the area of infrastructure for nuclear and radiological materials management. Specifically, several key facilities at the Savannah River Site (including H-Canyon/HB-Line, L-Basin, and K-Area) support the receipt, storage, and disposition of plutonium and spent nuclear fuel. These facilities directly support meeting nuclear nonproliferation commitments by enabling the removal of HEU spent fuel and separated plutonium from foreign countries. Aging infrastructure and lack of sustained funding for maintenance and recapitalization continues to strain the ability of the Savannah River Site to support these critical missions.

The use of the Savannah River Site's H-Area Facilities to convert various forms of plutonium to oxide as part of the material disposition process illustrates the difficulty of operating aging nuclear facilities. The start of operations was delayed numerous times, due in part to three revisions of the DOE-STD-3009

Documented Safety Analysis and a suspension of the DOE Readiness Assessment to address concerns with HB-Line Conduct of Operations. Authorization to begin operations was achieved in August 2014 upon subsequent implementation of the necessary corrective actions. But since operations began, there have been at least two pauses in activity due to significant issues involving criticality safety control violations.

Figure 26. Storage Operations at WIPP (Carlsbad, NM)

In addition to the materials processing capabilities at the Los Alamos National Laboratory and the Savannah River Site, DOE/NNSA depends on facilities at other sites to receive, store, and dispose of nuclear and radiological materials. Ultimately, DOE/NNSA's ability to achieve permanent threat reduction depends on access to storage and disposal pathways for nuclear and radiological materials. But DOE/NNSA's access to facilities important to these disposal pathways has been impaired due to the 2014-2017 suspension of operations at WIPP in Carlsbad, NM (now reopened), and regulatory issues in several other states. DOE/NNSA is working collaboratively with other DOE offices to address these issues. The DOE/NNSA ORS also supports the NRC's consideration of potential mechanisms for radioactive source users to set aside funding to eventually transport and dispose of their radiological sources. This would shift some of the financial burden for radiological threat reduction from the U.S. Government to the radioactive source users, and also would provide incentive for those users to transition from using radioactive sources to using alternative, non-radioisotopic technologies.

Managing Infrastructure Consolidation

Efforts to consolidate DOE/NNSA infrastructure offer tremendous benefits across the enterprise, but they also pose potential challenges that must be carefully managed, especially for counterterrorism and counterproliferation activities. CTCP relies almost exclusively on infrastructure maintained and primarily used by the SSP, including experimental facilities, computational and modeling assets, and explosives facilities and capabilities. While CTCP may use only a small portion of these assets' total capacity, this limited use supports unique and critical national security efforts. Moreover, while similar experimental facilities may exist at multiple locations, there are often important differences in the capabilities of these facilities that are highly relevant for the CTCP mission.

CTCP is coordinating closely within DOE/NNSA to ensure that potential infrastructure consolidation decisions do not adversely impact its mission. This intra-DOE/NNSA coordination provides improved clarity and transparency regarding the physical infrastructure base needed to support the CTCP mission.

Maintaining Operational Readiness for Emergency Response Assets

The core of DOE/NNSA's emergency response capability is a cadre of deployable personnel who are trained to respond to nuclear or radiological incidents. Effectively equipping these response teams with the necessary, highly specialized equipment can pose a significant challenge. The threat of nuclear and radiological terrorism is inherently dynamic, and changes in the threat environment can drive requirements for new or updated equipment. The evolving nature of the cybersecurity environment and national cybersecurity standards can also drive changes in equipment requirements. Additionally, the emergency response mission is closely coordinated with a number of interagency partners, including the

FBI. Equipment interoperability across organizations is therefore critical, especially for communications equipment. Such systems must also be highly mobile, reliable, and secure. Finally, equipment must be periodically replaced as it reaches the end of its useful life. Together, these demanding requirements for emergency response equipment constitute an important infrastructure challenge. The DOE/NNSA emergency response program is investing in equipment recapitalization, but DOE/NNSA has also had to make some necessary corporate decisions that has deferred some planned procurements to support other financial needs.

5.5 Human Capital

5.5.1 Current Status

DOE/NNSA's NTR mission leverages the workforce within the nuclear security enterprise, as well as at laboratories managed by DOE's Office of Science, Office of Nuclear Energy, and Office of Environmental Management. The M&O workforce at each laboratory, plant, and site performs work for multiple program offices. This model allows DOE/NNSA to have direct, targeted access to experts across a wide variety of fields. For example, DOE/NNSA can engage experts in the physical security of U.S. nuclear facilities to help improve the security of nuclear materials abroad or leverage U.S. nuclear reactor designers and fuel development experts to assist in converting research reactors from HEU to LEU fuel.

Leveraging the unique national facilities and assets described above, these scientists and technical specialists perform the work needed to develop technical and policy approaches to nuclear nonproliferation and counterterrorism challenges; characterize, detect, and defeat nuclear threat devices; and respond to and manage the consequences of nuclear or radiological incidents. The workforce also supports international cooperative activities and dialogues in nuclear nonproliferation, nuclear security and counterterrorism; WMD counterterrorism TTXs; and nuclear information security policy and practices.

The breakdown of the laboratory, plant, and site workforce supporting the nuclear and radiological threat reduction mission, measured in total full-time equivalents (FTEs) as of the end of FY 2016, is shown in Figure 27. This graphic includes employees directly supporting DOE/NNSA's threat reduction programs as well as the pro-rated share of the "indirect" workforce (i.e., those workers supporting the general operation of the laboratory, plant, or site).

Working closely with the laboratories, plants, and sites, DOE/NNSA's federal workforce carries out a number of critical functions in support of the nuclear and radiological threat reduction mission, including supporting the negotiation of nuclear and radiological security cooperation with foreign countries, carrying out informed technical oversight of M&O work activities, developing budgets, evaluating program effectiveness, managing contracts, and establishing program strategic direction. The functions and staffing levels for the federal workforce, measured as the total number of employees as of the end of FY 2016, are represented in Figure 28.

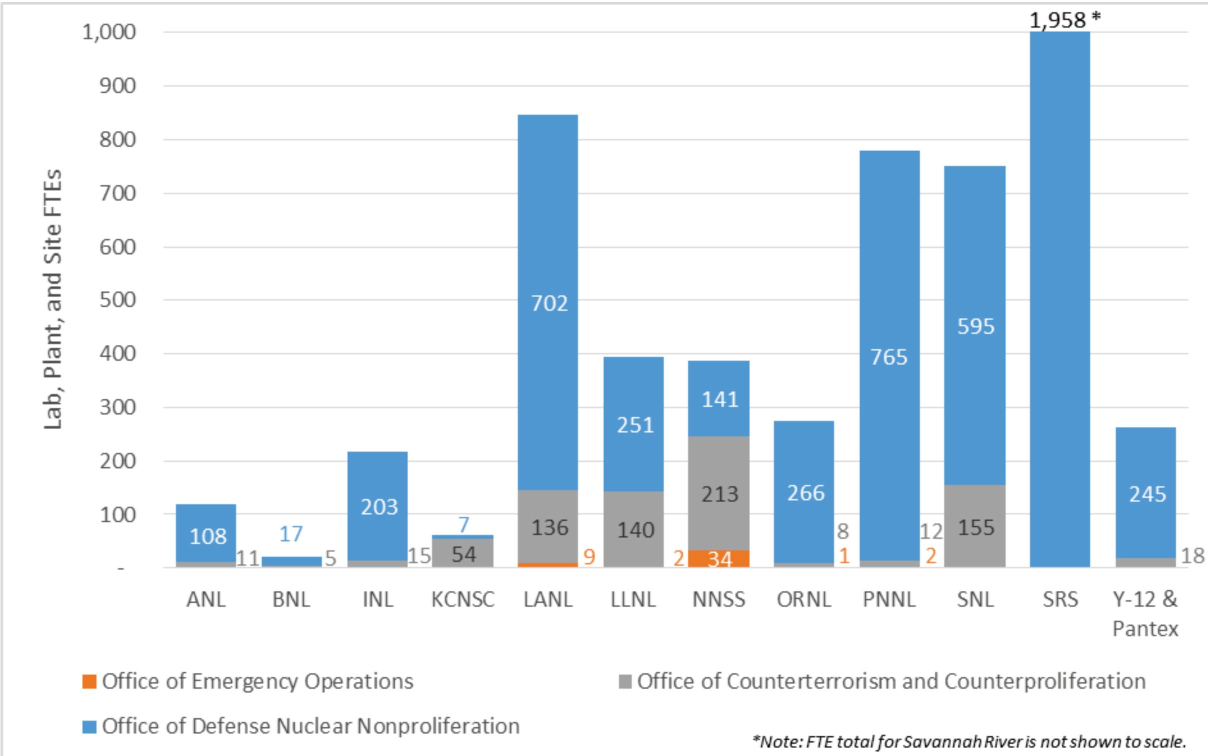


Figure 27. FY 2016 Laboratory, Plant, and Site Workforce Supporting Nuclear and Radiological Threat Reduction by Program Office (FTEs)

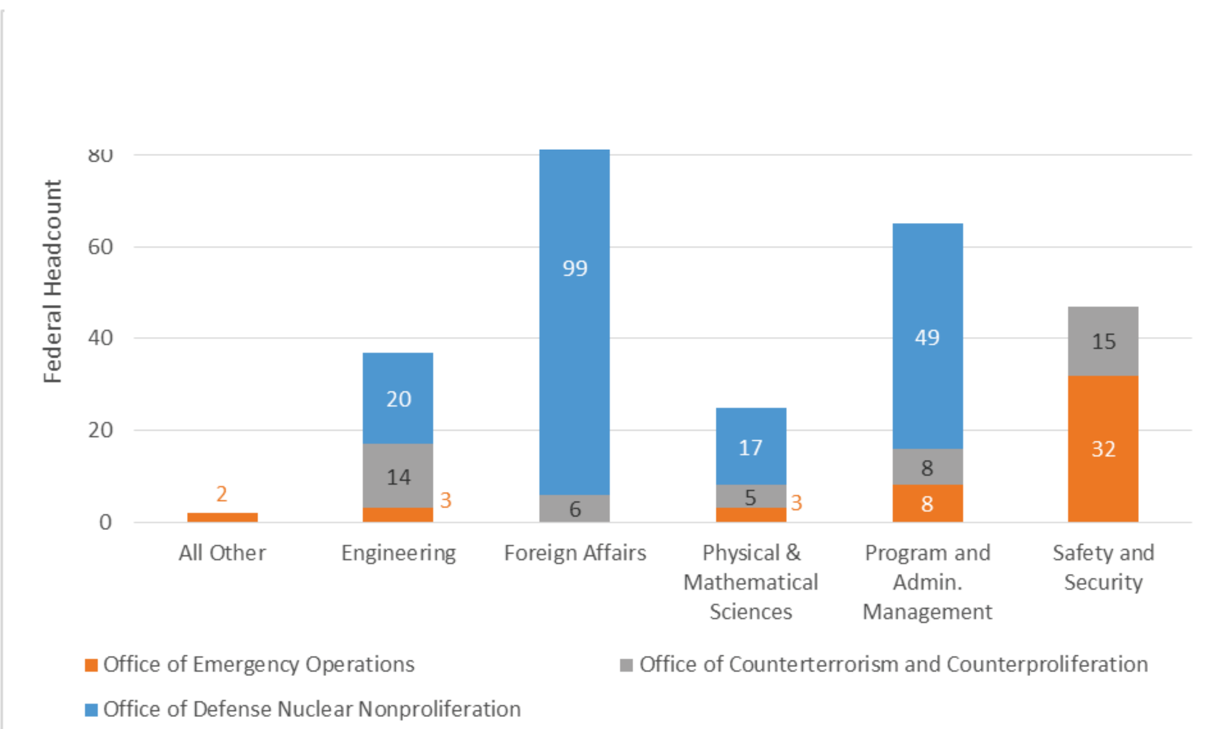


Figure 28. FY 2016 Federal Workforce Supporting Nuclear and Radiological Threat Reduction by Job Function (Headcount)

5.5.2 Key Workforce Challenges and Responses

Sustaining the Human Capital Base

Executing the nuclear and radiological threat reduction mission depends on a highly skilled, technically focused, and disciplined workforce. Given the specificity of the required skill sets, the human capital base must be carefully managed to ensure that qualified personnel are available to backfill for those retiring or moving to different positions. This important issue affects both the federal and M&O workforce supporting DOE/NNSA's NTR mission.

A significant portion of the DOE/NNSA federal workforce supporting nuclear and radiological threat reduction is eligible for retirement within the next five years. Managing the impact of these retirements will require recruitment of both experienced and entry-level staff. As DOE/NNSA backfills retirees with new staff, the organization is seeking, where possible, to fill entry-level positions with staff having advanced technical degrees relevant to those jobs. A key tool in this recruitment effort is the NNSA Graduate Fellowship Program (NGFP), a year-long program for graduate-level students interested in careers in nuclear security. This program originally served DNN, but has since been broadened to recruit fellows for offices across all of DOE/NNSA. The NGFP Class of 2015–2016 included 39 Fellows, of whom over 40 percent had backgrounds in science, technology, engineering, or mathematics. After completing the fellowship, over 75 percent of the class secured employment within the DOE/NNSA complex.

With regard to the M&O workforce, DOE/NNSA's nuclear and radiological threat reduction programs use a number of mechanisms to manage the challenge of workforce transition and the retirement of specialized personnel. One such mechanism is the university-based research consortia described earlier in this report (Section 2.4 and Section 5.3), which link students with world-class researchers and introduce them to career possibilities at the national laboratories. Another important tool is the Safeguards Human Capital Development program, which is a component of the NGSI (described in Section 2.3) and is designed to address the specific human capital challenges in the area of international nuclear safeguards. The program cultivates sustainable academic and technical programs that recruit, educate, train, and retain the next generation of international safeguards professionals, resulting in a pipeline of new talent into the national laboratories and into positions at the IAEA.

In addition to these tailored programs, the nuclear and radiological threat reduction mission also relies heavily on DOE/NNSA-wide initiatives for workforce retention and recruitment. This includes Laboratory and Plant Directed Research and Development, which is key to continuing to challenge and intellectually stimulate the existing workforce, and to attract the next generation of talent. Also, DOE/NNSA's stockpile stewardship and weapons maintenance programs are striving to develop new approaches to sustaining the nuclear security enterprise workforce in order to maintain the responsiveness of the nuclear weapons complex. This responsiveness program will also help ensure that this specialized workforce and expertise will be available for leveraging by DOE/NNSA's nuclear and radiological threat reduction programs, especially the CTCP program. (See *FY 2018 SSMP* Chapter 7 for more details on NNSA's sustainment of the nuclear security enterprise workforce.).

Managing a Matrixed Workforce

As described above, the M&O workforce supporting the nuclear and radiological threat reduction mission also performs work for other program offices. This matrixed workforce model allows DOE/NNSA to have direct, targeted access to experts across a wide variety of fields. While this model has many benefits, it

Sustaining the Talent Pool in Nuclear Safeguards

The international safeguards system is under more strain today than at any point in history, placing increased burdens on the IAEA's already limited resources. In addition, the workforce supporting international safeguards faces many of the same demographic challenges confronting the nuclear workforce as a whole, with high percentages of retirees expected in the near future. Studies estimated that of the international safeguards specialists working at the national laboratories in 2009, over 80 percent of them would be retired or transitioned to work in another field by 2026.

In response to a 2006–2007 study on challenges to the international safeguards system, DOE/NNSA established the safeguards Human Capital Development program to cultivate sustainable academic and technical programs that recruit, educate, train, and retain the next generation of international safeguards professionals. The program has built a pipeline of new talent into the national laboratories and into positions at the IAEA. Key elements of this effort include:

- **University Engagement**: The program incorporates international nuclear safeguards into graduate engineering curricula and develops university-laboratory partnerships to attract top-level students to the field. The program has worked with over two dozen universities to identify faculty leaders, develop or strengthen safeguards and nonproliferation course material, promote interdisciplinary education, provide guest lectures by laboratory subject matter experts, and encourage students to seek opportunities in the field.
- **Internship Opportunities**: The program offers students the opportunity to pursue summer safeguards internships at nine DOE national laboratory locations. The interns are matched with senior mentors and given the opportunity to work directly on DOE/NNSA safeguards projects to gain hands-on knowledge of safeguards technologies. Since 2008, the program has sponsored more than 500 internship positions across the national laboratory complex.
- **Short Courses**: Short courses give students and professionals the opportunity to study a specific safeguards topic, typically at a national laboratory or nearby university. The program sponsors six to eight short courses each year (reaching approximately 200 students annually) and uses interactive and hands-on approaches. The majority of courses are open to an international audience.
- **Professional Development**: The professional development component of the program aims to engage and retain early- and mid-career professionals in the safeguards field. Efforts include providing access to training materials and courses and encouraging involvement with DOE/NNSA-sponsored safeguards projects at the national laboratories. The program also sponsors post-doctoral fellows at eight national laboratories. Eighty percent of post-doctoral fellows have converted to full-time laboratory staff.

also poses certain challenges that must be carefully managed, especially as related to the counterterrorism, counterproliferation, and emergency response missions.

Most DOE/NNSA laboratory, plant, and site employees supporting these missions do so on a part-time basis, with the majority of their time allocated to the nuclear weapons mission of DOE/NNSA's Office of Defense Programs. In particular, DOE/NNSA relies upon the availability of highly qualified part-time personnel to field and sustain its premier incident response capabilities, including teams such as the Accident Response Group, Search Response Team, and Joint Technical Operations Team. Also, the much larger nuclear weapons stockpile budgets command priority for staff time, and it can be difficult to access experts, such as weapons modelers and radiochemists, to support emergency response functions. For example, the vast majority of scientists with expertise in nuclear forensics spend less than 10 percent of their time supporting this capability. Moving forward, DOE/NNSA will continue to carefully manage the human capital base to ensure that all mission needs are being addressed.

5.6 Management and Operations

5.6.1 Current Status

DOE/NNSA is committed to delivering quality projects on schedule and on budget, and providing timely best-value acquisition solutions. In particular, the nuclear and radiological threat reduction mission depends on the application of safe, secure, and efficient management and operation principles to DOE/NNSA's global engagement efforts and project execution. To achieve this goal, the nuclear and radiological threat reduction activities are guided by relevant DOE and NNSA orders, guides, and supplemental directives.

5.6.2 Management and Operations Challenges and Responses

Effective Collaboration and Communication with Laboratories, Plants, and Sites

The DOE and NNSA complex of laboratories, plants, and sites is central to DOE/NNSA's ability to prevent, counter, and respond to nuclear and radiological threats. To further improve collaboration and communication in this area, DNN established the Laboratory Science Council in late 2014. As part of this initiative, DNN senior federal managers meet routinely with senior managers from the laboratories, plants, and sites. Issues raised during Laboratory Science Council meetings have resulted in the creation of specialized working groups that develop actionable recommendations for DNN senior management. These working groups have addressed issues such as cybersecurity, travel risk management, and metrics for nonproliferation training and education activities.

In addition to these program-specific coordination mechanisms, the nuclear and radiological threat reduction programs also rely heavily on broader DOE and NNSA initiatives in this area. One such mechanism is the National Laboratory Directors Council (NLDC), which collaborates with DOE on strategic issues and areas of broad interest across the enterprise. While the scope of the NLDC is significantly broader than nuclear and radiological threat reduction, it has made important contributions in this area, including a study of emergency response capabilities that produced a number of valuable recommendations for potential improvements.

Coordination of Programs to Prevent, Counter, and Respond to Nuclear and Radiological Threats

DOE/NNSA's integrated NTR strategy, as described in Chapter 1, requires close coordination across the DOE/NNSA Offices of Defense Nuclear Nonproliferation, Counterterrorism and Counterproliferation, and Emergency Operations. In order to enhance this coordination, in February 2015 DOE/NNSA proposed the alignment of all funding for preventing, countering, and responding to global nuclear dangers into a single appropriation. In late 2015, DOE/NNSA further integrated these critical activities by transferring a number of functions from its Office of Emergency Operations into its Office of Counterterrorism and Counterproliferation. This reorganization consolidates several related activities to improve collaboration and efficiency. The change also supports the Department's broader objective of improving its emergency management system; the Office of Emergency Operations is now assuming a more expanded leadership role within DOE to implement this all-hazards, enterprise-wide capability.

Chapter 6: Conclusion

The nuclear and radiological threat environment is highly dynamic. New threats can emerge—especially as a result of technological change—and persistent threats can abruptly become more acute. Sudden breakthroughs can, however, mitigate longstanding challenges. Events of the past year have illustrated the dynamic nature of the threat environment, including sophisticated cyber-attacks and terrorist threats in Western Europe and the United States.

Reducing the dynamic threats of nuclear proliferation and nuclear and radiological terrorism is one of DOE/NNSA's three mission pillars. DOE/NNSA's strategy to achieve this mission is to address the entire threat spectrum by preventing the acquisition of nuclear weapons or weapons-usable materials, countering efforts to acquire such weapons or materials, and responding to nuclear or radiological incidents.

DOE/NNSA's annual *Prevent, Counter, and Respond* report describes the nuclear and radiological threat environment, as well as DOE/NNSA's strategic approach to accomplishing its core NTR mission. To implement its program plans, DOE/NNSA makes full use of the DOE scientific complex and the DOE/NNSA nuclear security enterprise of national laboratories, plants, and sites, which are recognized as the world leaders in scientific, technical, and engineering expertise and infrastructure in the nuclear security area. Building on this foundation of more than 50 years of experience in nuclear weapons design, production, and security, the crosscutting capabilities of this complex provide the knowledge and skills, unique facilities, and highly-capable workforce necessary to implement the DOE/NNSA global nuclear security engagement strategy and program plans.

DOE/NNSA programs play a central role in U.S. interagency policy coordination, program coordination, and leveraging other expertise and capabilities within the U.S. national security interagency. DOE and NNSA also are the U.S. leads or co-leads on a wide set of bilateral, multilateral, and international nuclear security groups and forums, demonstrating DOE's leadership in global nuclear security and the global fight against nuclear proliferation and terrorism.

As DOE/NNSA assesses the evolution of nuclear threat trends over the FY 2018–FY 2022 timeframe, it will conduct strategic studies to validate that its efforts remain focused on both addressing current nuclear threats and anticipating emerging and evolving threat trends as far in advance as possible. Armed with these studies, and with the insights from external sources such as the U.S. interagency, foreign partners, and the international nuclear security community, DOE/NNSA will work with the DOE national laboratories, production facilities, and sites in conducting both cross-program and program-specific risk assessment and prioritization assessments. This will allow DOE/NNSA to make corporate decisions across the prevent-counter-respond mission space, which will align future program and investment priorities to address the greatest dangers to global nuclear security. To reflect such program progression, the *Prevent, Counter, and Respond* report will be updated regularly to reflect program plans, progress, and challenges across these mission areas.

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Appendix A
Requirements Mapping

This *Prevent, Counter, and Respond* report addresses the requirement for DOE/NNSA to submit a *Defense Nuclear Nonproliferation Management Plan* in Title 50, Section 2575, of the U.S.C., as added by the *FY 2016 National Defense Authorization Act*, Sec. 3132.

The reader can locate the information associated with each report requirement in the following matrix:

50 U.S.C. § 2575	NNSA Response
(a) In General.--- Concurrent with the submission to Congress of the budget of the President…in each fiscal year, the Administrator shall submit to the congressional defense committees a five-year management plan for activities associated with the defense nuclear nonproliferation programs of the Administration to prevent and counter the proliferation of materials, technology, equipment, and expertise related to nuclear and radiological weapons in order to minimize and address the risk of nuclear terrorism and the proliferation of such weapons.	N/A
(b) Elements.---The [plan] shall include, with respect to each defense nuclear non-proliferation program of the Administration, the following:	N/A
(1) A description of the policy context in which the program operates, including---	N/A
(A) a list of relevant laws, policy directives issued by the President, and international agreements; and	Appendix E
(B) nuclear nonproliferation activities carried out by other Federal agencies.	Appendix G
(2) A description of the objectives and priorities of the program during the year preceding the submission of the [plan].	Section 1.1
(3) A description of the activities carried out under the program during that year.	Appendix B
(4) A description of the accomplishments and challenges of the program during that year, based on an assessment of metrics and objectives previously established to determine the effectiveness of the program.	Appendix B
(5) A description of any gaps that remain that were not or could not be addressed by the program during that year.	Section 2.1.2, 2.2.2, 2.3.2, 2.4.2, 3.2, 4.1.2
(6) An identification and explanation of uncommitted or uncosted balances for the program, as of the date of the submission of the [plan] that are greater than the acceptable carryover thresholds, as determined by the Secretary of Energy.	Appendix F

50 U.S.C. § 2575	NNSA Response
(7) An identification of funds for the program received through contributions from or cost-sharing agreements with foreign governments…during the year preceding the submission of the [plan] and an explanation of such contributions and agreements.	Appendix C
(8) A description and assessment of activities carried out under the program during that year that were coordinated with other elements of the Department of Energy, with the Department of Defense, and with other Federal agencies, to maximize efficiencies and avoid redundancies.	Appendix G
(9) Plans for activities of the program during the five-year period beginning on the date on which the [plan] is submitted, including activities with respect to the following:	N/A
(A) Preventing nuclear and radiological proliferation and terrorism, including through—	N/A
(i) material management and minimization, particularly with respect to removing or minimizing the use of highly enriched uranium, plutonium, and radiological materials worldwide (and identifying the countries in which such materials are located), efforts to dispose of surplus material, converting reactors from highly enriched uranium to low enriched uranium (and identifying the countries in which such reactors are located);	Section 2.1
(ii) global nuclear material security, including securing highly enriched uranium, plutonium, and radiological materials worldwide (and identifying the countries in which such materials are located), and providing radiation detection capabilities at foreign ports and borders;	Section 2.2
(iii) nonproliferation and arms control, including nuclear verification and safeguards;	Section 2.3
(iv) defense nuclear research and development, including a description of activities related to developing and improving technology to detect the proliferation and detonation of nuclear weapons, verifying compliance of foreign countries with commitments under treaties and agreements relating to nuclear weapons, and detecting the diversion of nuclear materials (including safeguards technology); and,	Section 2.4
(v) nonproliferation construction programs, including activities associated with Department of Energy Order 413.1 (relating to program management controls).	Section 2.5
(B) Countering nuclear and radiological proliferation and terrorism.	Chapter 3
(C) Responding to nuclear and radiological proliferation and terrorism, including through— (i) crisis operations; (ii) consequences management; and, (iii) emergency management, including international capacity building.	Chapter 4

50 U.S.C. § 2575	NNSA Response
(10) A threat assessment, carried out by the intelligence community…with respect to the risk of nuclear and radiological proliferation and terrorism and a description of how each activity carried out under the program will counter the threat during the five-year period beginning on the date on which the [plan] is submitted and, as appropriate, in the longer term.	*Threat Assessment:* To be submitted separately by the DOE Office of Intelligence and Counterintelligence *Activity Descriptions:* Sections 2.1.3, 2.2.3, 2.3.3, 2.4.3, 2.5.3, 3.3, and 4.3
(11) A plan for funding the program during that five-year period.	Appendix D
(12) An identification of metrics and objectives for determining the effectiveness of each activity carried out under the program during that five year period.	Sections 2.1.1, 2.2.1, 2.3.1, 2.4.1, 2.5.1, 3.1, 4.1.1, and 4.2.1
(13) A description of the activities to be carried out under the program during that five-year period and a description of how the program will be prioritized relative to other defense nuclear nonproliferation programs of the Administration during that five-year period to address the highest priority risks and requirements, as informed by the threat assessment carried out under paragraph (10).	*Description of Activities:* Sections 2.1.3, 2.2.3, 2.3.3, 2.4.3, 2.5.3, 3.3, and 4.4 *Description of Prioritization:* Section 1.1, 1.3
(14) A description of funds for the program expected to be received during that five-year period through contributions from or cost-sharing agreements with foreign governments…	*For Contributions from Past Fiscal Year:* Appendix C (Note: Contributions in future years are possible but cannot be projected in advance.)
(15) A description and assessment of activities to be carried out under the program during that five-year period that will be coordinated with other elements of the Department of Energy, with the Department of Defense, and with other Federal agencies, to maximize efficiency and avoid redundancies.	Appendix G
(16) Such other matters as the Administrator considers appropriate.	N/A
(c) Form of Report - The plan required by subsection (a) shall be submitted to the congressional defense committees in unclassified form, but may include a classified annex if necessary.	N/A
S. 2804 (accompanying report)	**NNSA Response**
NNSA shall … provide the Senate and House Appropriations Committees with a report that:	N/A
demonstrates how NNSA prioritizes threats to national security; and	Chapters 2, 3, and 4
links the budget request to those threats.	Appendix D

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Appendix B
FY 2016 Accomplishments

Accomplishments and Challenges in the "Prevent" Functional Area

FY 2016 Key Accomplishments	Challenges
Material Management and Minimization	
Nuclear Material Removal	
▪ Removed or confirmed the disposition of over 750 kg of WUNM (enough material for 30 nuclear weapons) from 10 countries. This included the removal of all separated plutonium from Switzerland, the removal of excess HEU and plutonium from Germany, the down-blending of all remaining HEU in Argentina, and the removal of all HEU and separated plutonium—over 500 kg in total--from Japan's Fast Critical Assembly. Overall, over 6,100 kg of material has been removed or confirmed disposed since the program's inception. ▪ Eliminated all HEU from Argentina, Indonesia, and Poland, resulting in all of Latin America and all of Southeast Asia now being free of HEU. Over the program's lifetime, 31 countries and Taiwan have been declared HEU-free (as defined as less than 1 kg remaining per country). ▪ Entered into follow-on cooperative agreements with three commercial entities to establish a reliable domestic source of Mo-99 medical isotopes that will be produced without the use HEU. These follow-on cooperative agreements (which are 50/50 cost-sharing arrangements) mark the completion of the full $25 million NNSA contribution commitment toward each commercial project.	▪ Political challenges remain an obstacle to the removal of HEU and plutonium from certain countries. ▪ Technical challenges limit the types of nuclear material that can be brought back to the United States.
Conversion	
▪ Converted China's Prototype Miniature Neutron Source Reactor to LEU fuel. ▪ Converted Kazakhstan VVR-K reactor to LEU fuel. ▪ Verified that Japan's Fast Critical Assembly is no longer using HEU fuel pending its conversion to a non-HEU fueled accelerator.	▪ Technical challenges related to producing new and unique fuel systems on a commercial scale for the conversion of high performance research reactors. ▪ Technical development of LEU targets and process chemistry needed for the conversion of the Mo-99 facilities located in Europe. ▪ Market forces within the commercial Mo-99 industry that in some cases have slowed customer

FY 2016 Key Accomplishments	Challenges
	uptake of LEU-based Mo-99 delayed the process of fully converting to LEU targets. ▪ Financial challenges for some domestic Mo-99 partners to raise private (non-federal) funding.
Material Disposition	
▪ Down-blended a cumulative 154 MT HEU under the HEU disposition program. ▪ Disassembled multiple surplus pits, as well as surveillance pits, upon resumption of pit disassembly operations in PF4 at Los Alamos National Laboratory after two and a half years of being in suspended operations due to criticality safety concerns. ▪ Resumed plutonium oxide production activities at HB-Line at Savannah River Site after recovering from a criticality safety procedure violation. ▪ Completed pre-conceptual design of the project to prepare material received from Japan under the gap removal program for disposition. ▪ Completed activities to support transition to a dilute and dispose alternative for surplus plutonium disposition—initiated pre-conceptual design to increase down-blend capability and began development of a comprehensive lifecycle estimate. ▪ Held the Second International Roundtable, bringing together international partners from the United Kingdom, France, Japan, IAEA, and the United States to share best practices and lessons learned and report on findings from collaborative projects related to plutonium management. ▪ Led plutonium management meetings with the United Kingdom and Japan to effectively develop plutonium management strategies to ensure that plutonium remains secure and that stocks are reduced over time.	▪ Consistent with congressional appropriations, the Office of Material Disposition is continuing construction activities on the MOX project to support the MOX fuel approach to plutonium disposition until a final decision to terminate the MOX project and begin the dilute and dispose approach is made.
Global Material Security	
International Nuclear Security	
▪ Supported the opening of the China COE on nuclear security in March 2016. ▪ Conducted nuclear security best practice exchanges and training workshops with 25 partner countries and the IAEA.	▪ Managing risks associated with the increasing number of emerging nuclear states. ▪ Greater emphasis on safety over security among some international partners. ▪ Continued terrorist interest in acquiring nuclear materials and/or targeting nuclear facilities. ▪ Accelerated growth and increased dynamism of cyber threats.

Radiological Security	
▪ Completed security upgrades at a cumulative total of more than 2,090 buildings worldwide with high-priority radioactive sources. ▪ Trained more than 4,000 domestic law enforcement and responders how to respond safely and quickly to prevent the theft of radiological materials. ▪ Recovered more than 7,000 radioactive sources from locations domestically and internationally, resulting in the cumulative total of more than 56,000 sources recovered. ▪ Continued development of advanced detection, delay, and tracking tools to support the radiological security mission at home and abroad. ▪ Initiated pilot activities for the promotion of alternative technologies internationally. ▪ Identified eight partners in the United States interested in converting their radioactive source-based device to a device that does not use radioactive sources. ▪ Drafted "*Best Practices Guide for Federal Agencies on Transitioning from High-Activity Radioactive Sources to Non-Radioisotopic (Alternative) Technologies,*" along with the NRC and the National Institutes of Health.	▪ Need for sustained commitment to radiological security and more nuanced understanding of the threat; continued U.S. leadership in addressing radiological security vulnerabilities. ▪ Need to reinforce the importance of a timely and effective response to alarm incidents to prevent the theft of radiological material. ▪ Need for international consensus on end-of-life management for radioactive sources, including repatriation, disposition, or long-term secure storage. ▪ Additional financial and technical support needed to promote alternative technologies for radioactive sources. ▪ Volatile security environments can cause project delays and disruptions in many regions, especially Africa and the Middle East. ▪ Insufficient or unclear regulatory authority and set of regulations on source security in many developing countries, which is necessary for a country to have sustainable source security.
Nuclear Smuggling Detection and Deterrence	
▪ Deployed fixed radiation equipment to 31 high-priority sites and provided 21 additional mobile and man-portable systems for use at land borders and internal checkpoints. ▪ Continued to build capacity through more than 119 operator and maintenance trainings; supported 44 workshops, exercises, and drills; and transitioned 50 sites to indigenous sustainability. ▪ Initiated engagement to build nuclear forensic capability with Algeria, Argentina, and Israel.	▪ Effectively communicating the importance of both fixed and mobile detection technologies as critical elements of a multilayered approach to preventing nuclear smuggling. ▪ Finding effective ways for partner countries to assume responsibility for deployed systems in spite of their internal resource constraints, political instability, and other factors that may impact transition timelines.
Nonproliferation and Arms Control	
Nuclear Safeguards	
▪ Continued to build nuclear safeguards capacity by conducting more than 60 training courses and technical exchanges with foreign partners related to nuclear safeguards. ▪ Completed seven physical protection assessments at foreign facilities holding U.S.-obligated material. ▪ Conducted 11 field trials and demonstrations of advanced nuclear safeguards technologies and tools in partner facilities. ▪ Tested and transferred five safeguards tools to the IAEA and foreign partners to make safeguards measurements more effective and efficient.	▪ Growing number of nuclear facilities and increasing amount of nuclear materials under IAEA safeguards outpacing the IAEA's resources in an era of a flat (or zero-growth) budget. ▪ Potential resource demands that could be imposed by sudden, transformative events. ▪ Partner countries have limited capability to incorporate additional resources, funding, and staff continuity. ▪ Difficulty attracting and retaining mid-career experts in the safeguards field. ▪ Gaining access to facilities to conduct bilateral physical protection assessment visits is contingent

▪ Completed successful Warhead Verification Workshop at Los Alamos National Laboratory, bringing together experts from across elements of the nuclear security enterprise to examine potential warhead verification approaches and identify targeted research and development requirements for the future. ▪ Continued to develop and maintain capabilities to verify nuclear programs in countries of concern, including performing qualification exercises to assess deployment readiness of equipment and procedures and conducting specialized personnel training for three verification teams.	on host government agreement and cooperation to support such visits.
Nuclear Controls	
▪ Conducted approximately 6,000 technical reviews of U.S. dual-use export licenses and completed approximately 3,000 technical analyses supporting U.S. detection and interdiction of WMD-related commodity transfers to foreign programs of concern. ▪ Supported the implementation of Procurement Working Group activities under the JCPOA with Iran through reviews of proposed transfers of controlled items to Iran. ▪ In cooperation with U.S. interagency programs, such as the DOS's Export Control and Related Border Security program, conducted 87 export control training courses and workshops in 37 countries, as well as with five regional/multilateral organizations to strengthen capacity in export control licensing, enforcement, and enterprise outreach. ▪ Held 17 training events for U.S. export control enforcement agencies. ▪ Supported the World Customs Organization's new Strategic Trade Control Enforcement training program by sending an expert to assist with the development of the curriculum and by providing experts to participate in regional seminars. ▪ In partnership with the DOS Export Control and Related Border Security program, held the 3rd Asia-Pacific Strategic Trade Experts Network meeting in Kuala Lumpur, Malaysia, focused on strengthening export control enforcement in the region.	▪ Some international partners have limited capacity to engage in bilateral and regional export control cooperative arrangements, which may curtail the extent of cooperation possible in a given fiscal year.
Nuclear Verification	
▪ Provided continued arms control implementation support, including through the New START Treaty Bilateral Consultative Commission, and the U.S. Backstopping Committee and Verification and Compliance Analysis Working Groups for the New START, INF, and Open Skies Treaties.	▪ Russia's ongoing violation of the INF Treaty and its potential implications. ▪ Countries of concern unwilling to uphold previous nonproliferation agreements and unwilling to negotiate new agreements.

▪ Completed annual monitoring visits in Russia under the terms of the U.S.-Russia PPRA to ensure the non-weapons use of Russian plutonium oxide and non-operational status of shutdown Russian plutonium production reactors; hosted Russian monitors at U.S. facilities falling under the PPRA. Held JEV in Seversk, which will help lead to monitoring of two of the last three shutdown Russian reactors. ▪ Maintained the capability to exert U.S. verification rights under the LTBT, the TTBT, and the Peaceful Nuclear Explosions Treaty. ▪ Worked with the Preparatory Commission for the CTBTO to strengthen operation of the IMS, supported by the IDC. Hosted Familiarization Activity at NNSS for CTBT OSI experts. ▪ Developed and assessed advanced technologies and concepts for future warhead and fissile material transparency and verification regimes that protect U.S. national security interests while enabling U.S. policy objectives. ▪ Developed, tested, and evaluated verification procedures and technologies to monitor, verify, and dismantle uranium and plutonium weapons activities in countries of concern. ▪ Continued to provide operations planning and training and maintained readiness of U.S. verification teams, technologies, and capabilities to support the verifiable dismantlement of nuclear programs in countries of proliferation concern. ▪ Continued to maintain OPCW Designated Laboratory at Lawrence Livermore National Laboratory to support implementation of the CWC.	
Nonproliferation Policy	
▪ Concluded negotiations of civil nuclear cooperation agreement (123 Agreement) with Norway. Achieved entry into force of successor 123 Agreements with China and the Republic of Korea. Concluded negotiations of Administrative Arrangements to the 123 Agreements with the Taipei Economic and Cultural Representative Office, Vietnam, and the Republic of Korea. ▪ Continued to implement a Part 810 process improvement plan and e810 online authorization system to further improve and modernize the 810 process. ▪ Built innovative Track 1.5 engagement activities in South Asia, Southeast Asia, and the Middle East, as well as unique social media activities in South Asia, to address emerging challenges and opportunities in nonproliferation and arms control.	▪ Managing the balance between the nonproliferation objectives of Part 810 and the benefits of U.S. commercial participation in foreign civil nuclear power programs. ▪ Continuing strains on the NPT as the cornerstone of the international nonproliferation regime and the growing need to support progress across the three pillars of the treaty: disarmament, nonproliferation, and the peaceful uses of nuclear energy. ▪ Managing external challenges to the nonproliferation regime, including global change, technological advancement, political unpredictability, and countries of concern actively pursuing WMD. ▪ Tensions between India and Pakistan.

Defense Nuclear Nonproliferation Research and Development	
Proliferation Detection	
▪ Successfully executed the fifth and sixth experimental shots of the SPE at the Nevada National Security Site. ▪ SBIR grant recipient Stellarray Inc. awarded for their work on “smart X-ray sources,” a self-contained blood irradiator. The work is based on its proprietary flat panel x-ray source, which will replace the cesium-137 irradiators now used to irradiate blood for the prevention of transfusion-associated graft versus host disease. ▪ At the Nevada National Security Site, demonstrated technologies, system evaluation methods, and three different approaches in warhead monitoring under a hypothetical future arms control initiative. This demonstration to a select group of interagency representatives culminates a five-year effort by a team from Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Sandia National Laboratories, Pacific Northwest National Laboratories, and the Nevada National Security Site. ▪ The Underground Nuclear Event Signatures Experiment (UNESE) team successfully injected radiochemical tracers into a previous underground nuclear test cavity at the Nevada National Security Site. This experiment will further enhance U.S. capabilities to detect, locate, and identify underground nuclear events. ▪ The Remote Detection of Uranium Conversion Venture completed several milestones, including PATRONUS, a joint United Kingdom—NNSA field campaign involving collecting airborne and ground data at two UK civil nuclear material production sites. PATRONUS improved existing remote detection systems as well as tested a new capability for remote optical detection. ▪ In a cooperative project with DTRA and 13 interagency partners, DNN R&D successfully executed a one-month campaign at the Nevada National Security Site to advance the development of the next generation of sensors and models to detect and characterize foreign nuclear weapons program activities. ▪ A five-year, $5M/year, grant was awarded to the Nuclear Science and Security Consortium, led by the University of California at Berkeley. The consortium teams join universities with DOE national laboratories to conduct nuclear science and engineering research with the goal of developing the next generation of nuclear scientists	▪ Full integration of emerging interagency-identified requirements.

and engineers. This particular grant supports the non-mission-related research and development part of the IUP established by Congress in 2009.	
Nuclear Detonation Detection	
▪ Delivered the GBD-III-4 and -5 payloads to the U.S. Air Force, which were successfully launched and tested-on-orbit on the GPS Block II-F-11 and -12 satellites. ▪ Reviewed and finalized the design for the SENSER payload, which will validate the performance of next generation sensor technologies in a space environment. The process continued into FY 2017 for payload delivery to the U.S. Air Force in FY 2018. ▪ Sandia National Laboratories developed a new approach for searching historical archives for similar waveforms that is several orders of magnitude faster than other waveform correlation type search algorithms and could be revolutionary in engendering greater use of historical nuclear explosion data for waveform correlation research and operational detectors. ▪ Research outcomes improved the nation's capabilities for characterization and analysis of bulk nuclear materials and detonations of devices of unknown origin. Sponsored research focused on reducing limitations or uncertainties in current techniques, and on emerging methods.	▪ Mitigating supply-chain interruptions and meeting deliverables requiring special chip fabrication during a rapidly consolidating global manufacturing market. ▪ Design, procurement, production, and integration dependencies on a yet-to-be-decided long-term acquisition strategy for geosynchronous sensing.

Accomplishments and Challenges in the "Counter" Functional Area

FY 2016 Key Accomplishments	Challenges
Nuclear Counterterrorism and Incident Response	
Nuclear Counterterrorism Assessment Program	
▪ Successfully advanced experimental efforts to build predictive capabilities for rendering safe nuclear threat devices; executed innovative, exploratory standoff disablement activities to meet DOD operational requirements; and directly supported the National Security Council in developing and implementing nuclear counterterrorism and nuclear counterproliferation policies. ▪ NNSA's atmospheric modeling capabilities were used for several real-world events and proactive alerts. ▪ Provided more than 30 analyses of unknown nuclear materials in support of DOD; DHS (Secret Service); Department of Justice (DOJ [FBI]); DOS; and various state governments, including Ohio, Tennessee, and Pennsylvania. ▪ Provided operational and technical expertise to support the U.S. Secret Service and FBI during several national security special events, including the Nuclear Security Summit in Washington, DC; the Republican and Democratic national party conventions in Cleveland, OH, and Philadelphia, PA; the 2016 Olympic Games in Rio de Janeiro, Brazil; and Super Bowl 50 in Santa Clara, CA.	▪ Additional depth is needed in technical reachback capacity at the nuclear weapon Laboratories to allow peer review of nuclear assessments in support of the Nuclear Incident Response mission and to develop the next generation of laboratory technical experts for enduring capabilities. ▪ Reinvigoration of the RAP teams is needed to further develop advanced tactics, techniques, and procedures; and train RAP and NRAT jointly with FBI. With years of insufficient resources and increasing mission, the RAP teams' core capabilities have deteriorated. Additional training, equipment and outreach is needed to support radiological planning, preparedness and response operations, in support of Federal, State and local officials.
Counterterrorism Response and Capacity Building	
▪ Provided radiation detection capabilities to more than 16 countries and assisted with radiation overexposure incidents, source recovery operations, and emergency operations center connectivity. ▪ Partnered with DOS to offer three *Eminent Discovery* training and TTXs to help non-nuclear international partners better understand the threats of WMD terrorism and illicit commodity trafficking and develop a response plan to safely disposition any material seized. In 2016, one of NNSA's international partners (who had hosted an *Eminent Discovery* exercise in 2012) intercepted and seized smuggled radiological material, demonstrating the value of this training to reduce threats far from U.S. shores.	▪ Partner countries have limited capability to incorporate additional resources, funding, and staff continuity. ▪ Requests for assistance outpace resources.

Accomplishments and Challenges in the "Respond" Functional Area

FY 2016 Key Accomplishments	Challenges
Emergency Operations	
▪ Restructured DOE/NNSA's emergency management and response programs to more effectively manage and coordinate an all-hazards approach to DOE's emergency preparedness and to support coordination efforts across the entire DOE complex and throughout the federal government. ▪ Established a National Incident Management System-compliant structure that receives strategic direction from the DOE Deputy Secretary's EIMC. ▪ Activated the National Incident Management System to support three severe weather events; no fewer than 10 national security special events; as well as for internal, national, and site-specific exercises held at Y-12 National Security Complex in Oak Ridge, TN; Idaho National Laboratory in Idaho Falls, ID; the Nevada National Security Site; and WIPP in Carlsbad, NM. ▪ Updated DOE/NNSA's COOP plans, and validated these updates during the 2016 Capstone Exercise that included an interagency component: the Eagle Horizon Continuity Exercise. Together, these exercises helped the United States integrate previously overlapping national continuity models to ensure continuing performance of essential national and government functions in the case of a catastrophic event.	▪ Coordination and synchronization of policy requirements as the new Administration promulgates goals and objective could impact the timely development and implementation of emergency management guidance. ▪ Operating under repeated Continuing Resolutions increases challenges to provide onsite technical support across the DOE complex as we simultaneously execute required administrative and policy across the Emergency Management Program. ▪ Training for preparedness personnel to facilitate Emergency Management Enterprise training programs. At present, no one in the Office of Preparedness is classified as a "training specialist." ▪ Not enough personnel to accomplish current and new requirements during routine operational tempo. • Overcome significant degradation in operational capability due to lack of personnel to support enhanced/emergency operations levels. • The Aerial Measuring System aircraft must be replaced in the immediate future as age-related issues will increasingly result in reduced reliability and availability of aircraft to perform monitoring for ground deposition of radioactive materials.

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Appendix C
Foreign Contributions and Cost-Sharing Agreements

Foreign Engagement

DOE/NNSA is the U.S. lead or co-lead in many key international engagements to cooperatively strengthen the global nuclear security regime. These partnerships extend the reach of DOE/NNSA programs and play a key role in demonstrating international support for action against the global nuclear proliferation and terrorism threat. This broader and ongoing engagement helps establish a level of confidence and trust that bolsters DOE/NNSA's ability to quickly engage the support of regional partners whenever a transformative event suddenly occurs.

U.S. foreign partners recognize NNSA and other parts of DOE as possessing world-leading expertise and infrastructure for strengthening nuclear security around the globe, and thus share the cost of program actions in pursuit of common nuclear security objectives and priorities with DOE/NNSA. DOE/NNSA nuclear nonproliferation programs have congressional authorization to receive direct financial contributions from foreign partners, and since FY 2005 these programs have received over $105 million (U.S. dollars [USD] equivalent) for designated projects from eight foreign countries. These contributions have enabled DOE/NNSA programs to implement cooperative nuclear security work that advances the mutual nonproliferation objectives of both the foreign partner and the United States.

Internationally, DOE has a strong and long-established partnership with the IAEA, and conducts multilateral consultations through forums such as the Nuclear Security Summits, the Global Initiative to Combat Nuclear Terrorism, the G7 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction, and the UN Committee implementing UN Security Council Resolution 1540. In addition, DOE/NNSA acts as the U.S. lead or co-lead in a number of bilateral cooperation coordinating bodies, including (but not limited to) the U.S.-China Peaceful Uses of Nuclear Technology Joint Coordination Committee, the U.S.-European Atomic Energy Community (EURATOM) Joint Coordination Committee, the U.S.-Japan Nuclear Security and Emergency Management Working Groups, and the U.S.-India Joint Working Group through India's Global Center for Nuclear Energy Partnership.

Under its counterterrorism/counterproliferation mission, DOE/NNSA sustains international technical and policy engagements with key allies and foreign partners, conducts bilateral counterterrorism security dialogues with other countries that maintain peaceful nuclear power programs, and coordinates outreach to strengthen WMD counterterrorism capabilities, domestically and abroad. For example, in support of the U.S.-UK-France Joint Statement on Nuclear Terrorism issued at the 2012 Nuclear Security Summit in Seoul and working closely with United Kingdom and French partners, DOE/NNSA continues its international engagements supporting approaches to reduce the attractiveness of nuclear materials to terrorists and continues sharing specialized knowledge to diagnose, render safe, characterize, and dispose of nuclear or radiological threat devices.

DOE/NNSA also works with key foreign partners to improve their incident response capabilities needed to address nuclear terror threats, accidents, or incidents. These strategic engagements with key partners are prioritized based on U.S. national security objectives and can include unclassified and classified technical exchanges, joint experiments, technical capability inter-comparisons, and joint operational trainings and exercises to strengthen nuclear preparedness and response. These mutually beneficial engagements strengthen the national, bilateral, and regional capabilities and coordination needed to quickly recognize, characterize, and respond to the broad range of nuclear and radiological threats.

International Contributions

The information in this appendix duplicates information in the annual report to Congress: *Receipt and Utilization of International Contributions to the Office of Defense Nuclear Nonproliferation of the National Nuclear Security Administration*.

Section 2569(f) of Title 50, United States Code, authorizes the Secretary of Energy to accept and use funds contributed by any person (including a foreign government, international organization, or multinational entity), for the purposes of programs within DNN. DOE/NNSA nuclear nonproliferation programs have benefited from partnerships and collaborations with foreign countries, including direct international financial contributions to designated projects and cost-sharing arrangements for those projects. These partnerships have extended the reach of DOE/NNSA programs and have played a key role in demonstrating international support for action against the global nuclear proliferation threat. Further, multilateral forums such as the G7 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction and the Nuclear Security Summit process help encourage foreign partner interest in project matchmaking, coordination, and leveraging of effort with DNN programs.

Since FY 2005, DNN programs have received over $105 million (USD equivalent) in direct financial contributions from eight countries.[4] During FY 2016, DNN received a total of $6,538,165 (USD equivalent) from five countries (Table 2). Additional contributions in future years are possible but cannot be projected in advance.

Table 2. Amount and Use of Received Foreign Contributions in FY 2016

International Contributor	Amount/Date Received	Use
Global Material Security		
Netherlands	$134,970 12/1/2015	Funds were used to support the *Apex Gold* event—a pre-2016 Nuclear Security Summit Ministerial-level scenario-based policy discussion on the implications of and responses to a hypothetical international nuclear security incident.

[4] Of this total, the now-completed Elimination of Weapons Grade Plutonium Production program—which assisted in the shutdown of three Russian plutonium production reactors—received a total of $31,152,517 USD in contributions from Canada ($7,319,453), Finland ($628,900), the Republic of Korea ($750,000), the Netherlands ($1,190,200), New Zealand ($308,000), and the United Kingdom ($20,955,964).

International Contributor	Amount/Date Received	Use
Republic of Korea	$465,000 12/31/2015	Funds were used to support physical protection upgrades for the State Agency of Ukraine for Management of the Exclusion Zone-Controlled Facilities storing radiological material, as well as the deployment of mobile radiation detection systems to Lebanese Armed Forces.
Canada	$1,943,489 3/8/2016	Funds were used to support the installation of radiation portal monitors at the Port of Callao in Peru as well as physical security equipment and training to the government of Malaysia to strengthen radiological security.
	$3,471,151 7/14/2016	Funds were used to support nuclear and radiological physical protection security upgrades and related training to Thailand, Malaysia, and Ukraine.
Finland	$307,895 5/19/2016	Funds were used to provide radiation detection equipment and maintenance support to Ukraine.
Norway	$215,660 8/23/2016	Funds were used to provide mobile radiation detection equipment to Ukraine.

Amounts Retained

All foreign funding contributions that were received in FY 2016 were obligated as of September 30, 2016, with the following exceptions:

- Because of construction delays in Peru, $1,049,489 of the contribution from Canada to install radiation detection portal monitors at the Port of Callao was obligated in the fourth quarter of FY 2017.
- A portion of the Republic of Korea's contribution—$215,000—to support deployment of radiation detection systems to the Lebanese Armed Forces was not obligated in FY 2017. The funds will be obligated in FY 2018.
- The $215,660 contribution received from the Kingdom of Norway to provide mobile detection equipment in Ukraine was obligated in FY 2017.

Cost-Sharing Arrangements

In addition, several DNN programs are developed on a targeted cost-sharing partnership basis with foreign partners, which bring financial, personnel, and technical resources to projects. This approach also helps strengthen the investment of the partner in the long-term sustainability of the program accomplishments.

M³: To the greatest extent possible, M³ shares the cost of its threat reduction activities with the host country and/or other partner countries that make contributions directly to M³, to the host country, or to the IAEA. In many cases, M³ pays for the equipment and U.S. expert labor/travel, while the host site/country pays for local labor. Bilateral arrangements with partner countries usually include a provision that the foreign counterparts are responsible for all labor and travel for government participants. These arrangements also include cost-avoidance measures such as no payment of foreign government taxes.

For nuclear material removal in high-income economy countries, DOE/NNSA has contracts with its foreign partners that stipulate the responsibilities (both financial and otherwise) for each shipment. Typically, the partner country pays all costs associated with packaging, loading, and transport of the material, as well as the fee charged by DOE/NNSA to accept the material. For example, in FY 2016, Switzerland and Germany sent HEU and separated plutonium to the United States, and paid for packaging, loading, transport, and DOE/NNSA acceptance fees. To support the five-year campaign (FY 2015–2019) transporting HEU spent fuel from Canada's Chalk River facility to the United States, Canada is covering the costs of packaging, transportation, and DOE/NNSA acceptance fees. And following the removal of all HEU and separated plutonium from Japan's Fast Critical Assembly in FY 2016, the United States and Japan have agreed to a six-year payment schedule for the disposition costs of the plutonium removed from the facility.

GMS: GMS has cost-sharing arrangements that vary depending on the partners involved and the types of project work. In some cases, GMS project costs are shared evenly (i.e., 50–50 split); in some cases, the country or that country's ministry/agency pays a larger share of the project costs; and in some cases, GMS pays a larger share. For example, in Ukraine, physical protection upgrades are conducted on a cost-share basis, with the U.S., Canada, and the Science and Technology Center of Ukraine supporting the procurement of equipment, and Ukraine supporting the installation and other labor costs. For some multi-year projects, there is a cost schedule whereby the partner assumes more of the cost share over time, until it eventually assumes all of the costs. GMS has also employed a new approach called "technical exchange" with some of its detection partners. With a technical exchange, GMS provides technical guidance while the partner procures and deploys detection equipment. GMS has used this approach in China. China's customs organization has invested tens of millions of dollars in procuring and installing detection systems, while GMS has provided technical support and consulting.

There are some projects where other U.S. programs join GMS program work, along with the partner country. For the new Nuclear Security COE in China, GMS and the DOD Cooperative Threat Reduction Program contributed technical support and training equipment, and the Chinese government supported all aspects of designing and constructing the COE and will support operation of the COE. China will contribute about $80–$120 million, and the U.S. contribution is about $45 million, shared between GMS ($35 million) and DOD ($5–10 million). GMS also continues to seek involvement of Global Partnership countries.

NPAC: NPAC has cost-sharing arrangements for the program's nuclear safeguards and export control capacity-building efforts that vary depending on the partners involved and types of project work. In FY 2016, NPAC shared the costs of capacity-building activities with a total of 53 countries and territories, including Algeria, Argentina, Armenia, Australia, Brazil, Bulgaria, Burma, Canada, Caribbean Community (CARICOM: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Lucia, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago), Chile, China, Croatia, European Union, France, Georgia, Germany, Hungary, India, Indonesia, Iraq, Israel, Italy, Japan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Malaysia, Malta, Mexico, Moldova, Morocco, Netherlands, Oman, Pakistan, Panama, Philippines, Portugal, Romania, Russia, Saudi Arabia, Serbia, South Africa, South Korea, Sri Lanka, Sweden, Tajikistan, Thailand, Turkey, Ukraine, United Arab Emirates, United Kingdom, and Vietnam, as well as the governing authorities on Taiwan. NPAC also had cost-sharing arrangements with several regional and international organizations, including the Arab Atomic Energy Agency, EURATOM, European Commission's Joint Research Centre – Institute for Transuranium Elements, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials, the Asia-Pacific Safeguards Network, the World Customs Organization, and the IAEA.

In most cases, NPAC subprograms provide funds for the travel and time associated with U.S. subject matter experts. Occasionally, NPAC subprograms will fund the fabrication costs of technology prototypes or the participation by collaborators from developing states to attend regional or international meetings. Other costs associated with joint activities—fees for local infrastructure, venues and services, equipment, overnight accommodations, among other things—are the responsibility of the country and/or organization that incurs them, subject to the availability of appropriated funds by the appropriate governmental authority and compliance with the laws and regulations applicable to the participants.

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Appendix D
FY 2018 Future Years Nuclear Security Program Plan

The following section comes directly from the Department of Energy FY 2018 Congressional Budget Request, Volume 1: National Nuclear Security Administration (May 2017).

In the FY 2018 President's Budget, the FY 2019–FY 2022 budget topline for NNSA reflects FY 2018 levels inflated by 2.1 percent annually. This out-year topline does not reflect a policy judgment. Instead, the Administration will make a policy judgment on amounts for NNSA's FY 2019–FY 2022 topline in the FY 2019 Budget, in accordance with the *Nuclear Posture Review* and *National Security Strategy* currently under development.

Table 3. Defense Nuclear Nonproliferation FY 2018 Funding

(Dollars in Thousands)

	FY 2016 Enacted	FY 2017 Annualized CR	FY 2018 Request	FY 2018 vs FY 2016
Defense Nuclear Nonproliferation Appropriation				
Defense Nuclear Nonproliferation				
Global Material Security				
International Nuclear Security	130,527	128,846	46,339	-84,188
Radiological Security	153,749	151,769	146,340	-7,409
Nuclear Smuggling Detection	142,475	140,640	144,429	+1,954
International Contributions [a] (non-add)	[6,538}	0	0	0
Total, Global Material Security	**426,751**	**421,255**	**337,108**	**-89,643**
Material Management and Minimization				
HEU Reactor Conversion	115,000	113,519	125,500	+10,500
Nuclear Material Removal	115,000	113,519	32,925	-82,075
Material Disposition	86,584	85,469	173,669	+87,085
Total, Material Management and Minimization	**316,584**	**312,507**	**332,094**	**+15,510**
Nonproliferation and Arms Control	**130,203**	**128,526**	**129,703**	**-500**
Defense Nuclear Nonproliferation R&D	**419,333**	**413,933**	**446,095**	**+26,762**
Nonproliferation Construction				
99-D-143 Mixed Oxide (MOX) Fuel Fabrication Facility, SRS	340,000	335,622	270,000	-70,000
18-D-XXX Surplus Plutonium Disposition (SPD) Project	0	0	9,000	+9,000
Total, Nonproliferation Construction	**340,000**	**335,622**	**279,000**	**-61,000**
Total, Defense Nuclear Nonproliferation Programs	**1,632,871**	**1,611,844**	**1,524,000**	**-108,871**
Nuclear Counterterrorism Incident Response Program	**234,390**	**231,372**	**277,360**	**+42,970**
Legacy Contractor Pensions	**94,617**	**93,399**	**40,950**	**-53,667**
Subtotal, Defense Nuclear Nonproliferation Appropriation	**1,961,878**	**1,936,614**	**1,842,310**	**-119,568**
Use of Prior Year Balances	**-21,576**	**0**	**0**	**+21,576**
Recission of Prior Year Balances	**0**	**0**	**-49,000**	**-49,000**
Total, Defense Nuclear Nonproliferation Appropriation	**1,940,302**	**1,936,614**	**1,793,310**	**-146,992**

* The FY 2017 Annualized CR amounts reflect the P.L. 114-254 continuing resolution level annualized to a full year. These amounts are shown only at the congressional control level and above.
[a] The international contributions received by the GMS program shown in the FY 2016 Enacted column are a non-add to the FY 2016 Appropriation. See Appendix C.

The Use of Prior Year Balances for FY 2016 includes $21,000,000 in prior year funding from Russia-related nonproliferation activities and $576,000 from funds set aside to meet the apportionment restriction related to NNSA pension funding.

Appendix E Relevant Laws, Policy Directives, and International Agreements

The nuclear and radiological threat reduction activities of the DOE/NNSA operate within the context of a large number of laws, PPDs, and international agreements and instruments. The most significant of these are listed below.

Laws

- *American Medical Isotopes Production Act of 2012*, Pub. L. 112-239, Div. C, Title XXXI, Subt. F.
- *Atomic Energy Act of 1954, as amended*, 42 U.S.C. §§ 2011 *et seq*.
- *Atomic Energy Defense Act, as amended*, 50 U.S.C. §§ 2501 *et seq*.
- *The Export Administration Act of 1979*, as amended, Pub. L. 96-72, as Continued by the President under the *International Emergency Economic Powers Act* pursuant to Executive Orders 12981 and 13222 as amended by Executive Order 13637.
- *Henry J. Hyde United States-India Peaceful Atomic Energy Cooperation Act of 2006*, Pub. L. 109-401, Title I.
- National Defense Authorization Acts (Various).
- *National Nuclear Security Administration Act, as amended*, Pub. L. 106-65, Div. C, Title XXXII.
- *Nuclear Non-Proliferation Act of 1978*, as amended, Pub. L. 95-242.

Presidential Policy Directives

- National Security Presidential Directive (NSPD) 28 (classified directive).
- NSPD 51/Homeland Security Presidential Directive 20.
- PPD-8: National Preparedness.
- PPD-25 (classified directive).

International Agreements and Other International Instruments

- Agreement between the Government of the United States of America and the Government of the French Republic for Cooperation in the Operation of Atomic Weapons Systems for Mutual Defence Purposes, as amended.
- Agreement between the Government of the United States of America and the Government of the Russian Federation Concerning Cooperation Regarding Plutonium Production Reactors, and the Amendment thereto (PPRA).
- Agreement between the Government of the United States of America and the Government of the Russian Federation Concerning the Management and Disposition of Plutonium Designated as No

Longer Required for Defense Purposes and Related Cooperation, with Annexes and Joint Statement, and Amendments thereto (also known as the U.S.-Russia Plutonium Management and Disposition Agreement, or PMDA).

- Agreement between the Government of the United States of America and the Government of the Russian Federation on Cooperation in Nuclear- and Energy-Related Scientific Research and Development.
- Agreement between the Government of the United States of America and the Government of the United Kingdom of Great Britain and Northern Ireland for Cooperation on the Uses of Atomic Energy for Mutual Defense Purposes.
- Agreement between the United States of America and the International Atomic Energy Agency for the Application of Safeguards in the United States (and the Protocol Additional thereto).
- Agreements for Peaceful Nuclear Cooperation pursuant to Section 123 of the Atomic Energy Act (Various).
- Convention on the Physical Protection of Nuclear Material and its 2005 Amendment.
- Comprehensive Nuclear-Test-Ban Treaty. (Note: The United States has signed but not ratified this treaty. The Treaty has not entered into force.)
- International Convention on the Suppression of Acts of Nuclear Terrorism.
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.
- Nuclear Security Summit Communiques from 2010, 2012, 2014, and 2016.
- The Joint Comprehensive Plan of Action.
- Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (also known as the LTBT).
- Treaty Between the United States of America and the Russian Federation on Measures for Further Reduction and Limitation of Strategic Offensives Arms (also known as the New Strategic Arms Reduction Treaty, or New START).
- Treaty Between the United States of America and the Union Of Soviet Socialist Republics on the Elimination of their Intermediate-Range And Shorter-Range Missiles (Intermediate-Range Nuclear Forces (INF) Treaty).
- Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Underground Nuclear Weapon Tests (also known as the TTBT).
- Treaty on the Non-Proliferation of Nuclear Weapons (Nonproliferation Treaty or NPT).
- United Nations Security Council Resolution 1540.

Appendix F
Analysis and Explanation of FY 2016 Uncommitted Balances

Background

When Congress appropriates annual funding for DOE programs, it generally specifies that the appropriated funds shall "remain available until expended." This means that any funds that have not been costed by the end of the fiscal year are carried over into the following fiscal year. These carry-over balances are necessary and unavoidable given the nature of the Department's work, but they are carefully managed and tracked as part of the Department's financial management system.

As part of its financial management system, DOE established percentage thresholds specifying levels of uncosted balances (as a percentage of total obligated funds) for specific types of financial and contractual arrangements. This allows the Department to evaluate its overall performance based on the variance between target thresholds and actual uncosted balances. A target threshold is defined as an analytical reference point beyond which uncosted obligation balances should be given greater scrutiny. Balances in excess of these thresholds require a more detailed explanation or justification to determine their cause and to identify the expectation for full costing. The target thresholds are 13% for contractor operating costs; 17% for federal operating costs; and 50% for Capital Equipment, General Plant Projects, and Accelerator Improvement Projects.

As per the requirements in the *FY 2016 National Defense Authorization Act*, Sec. 3132(b)(6) (50 U.S.C. § 2575(b)(6)), DNN reports to Congress annually on any unencumbered (i.e., uncommitted) balances that exceed these thresholds. Unencumbered balances include any funds that have been neither costed nor encumbered. Funds are encumbered through the award of direct contracts to non-M&O contractors, the award or issuance of subcontracts or purchase orders by M&O contractors to third parties, or certain other encumbering actions by M&O contractors. DNN measures its financial performance in terms of the percentage of funds that have been costed or encumbered, rather than just the percentage of funds that have been costed, because a great deal of the program's work is performed overseas, and sound management and programmatic necessities generally require work to be fully completed and verified before DNN disburses funds in non-U.S. venues. Measuring financial performance only in terms of funds costed would therefore not provide an accurate picture of the program's progress.

Overview of DNN Unencumbered Balances

At the end of FY 2016, the aggregate program costs plus encumbrances for DNN were 80.7% of total costing authority, leaving 19.3% unencumbered. Receipt of all FY 2016 funding six months into the fiscal year impacted the ability of many programs to feasibly encumber and cost available funds. This unencumbered balance was primarily driven by the following DNN congressional controls that had unencumbered balances in excess of the established thresholds:

- The International Material Protection and Cooperation (IMP&C) program (a past program, now reorganized into GMS program, which still has remaining unencumbered prior-year funds on account)
- The Global Material Security Program (GMS)

- The Material Management and Minimization Program (M^3)
- The Nonproliferation and Arms Control Program (NPAC)

Details on the unencumbered balances for each of these budget elements, explanations for the balances, and a table showing FY 2016 budget execution data in detail are provided below.

International Material Protection and Cooperation

As of the end of FY 2016, IMP&C costs and encumbrances totaled $382.8 million, or 66.0% of total FY 2016 available funds (all from FY 2015 or previous years' appropriations); the remaining $196.9 million in uncosted unencumbered balances (34.0% of available FY 2016 funds) exceeded the DOE threshold by $114.7 million. The uncosted unencumbered balance of $196.9 million will be used in FY 2017 to support multilateral engagement (such as with the IAEA), cybersecurity engagement, nuclear security training development and other bilateral nuclear security engagement with over 20 international partners. Some funds will be used to close out remaining work with Russia. The funds will also be used to support radiation detection sustainability efforts, including equipment testing and maintenance, workshops, and exercises in Armenia, Bulgaria, Kazakhstan, Ukraine, Malaysia, and Jordan.

Global Material Security

As of the end of FY 2016, GMS had costs plus encumbrances totaling $249.9 million, or 57.9% of its total FY 2016 available funds; the remaining $181.7 million in uncosted unencumbered balances (42.1% of available FY 2016 funds) exceeded the DOE threshold by $122.2 million. The uncosted unencumbered balance reflects the slow pace of multi-year upgrade efforts, as well as technical document and training development with multi-lateral and bilateral partners. A small portion of international contributions have specific conditions and take longer to spend down. Several contracts were delayed due to issues with specific partners related to the overall political situation, protracted negotiations, and travel restrictions. Unencumbered funds will be used to support high-priority activities in early FY 2017, including acceptance testing, site assurance visits, workshops and exercises, and maintenance contracts.

Material Management and Minimization

As of the end of FY 2016, M^3 had costs plus encumbrances totaling $228.6 million, or 72.3% of its total FY 2016 available funds; the remaining $87.4 million in uncosted unencumbered balances (27.7% of available FY 2016 funds) exceeded the DOE threshold by $46.6 million. The uncosted unencumbered balances support three critical programs within M^3, (1) HEU Reactor Conversion, (2) Nuclear Material Removal, and (3) Material Disposition.

The uncosted unencumbered balances for the HEU Reactor Conversion program ($14.0 million) will support placements of additional contracts in the Reactor Conversion and Mo-99 programs. The program used these funds to place key contracts in early FY 2017 for fuel qualification efforts and on Mo-99 cooperative agreements. These efforts further the M^3 goal of reducing the use of HEU in civilian applications worldwide by converting research reactors and isotope production facilities from HEU to LEU and by supporting non-HEU-based domestic production of Mo-99, a critical medical isotope used in 40,000 medical procedures daily in the United States.

The uncosted unencumbered balances for the Nuclear Material Removal program ($46.4 million) will support upcoming removal projects from Kazakhstan and Belarus; project close-out activities in Poland and Ukraine in the Russian-Origin Removal program; and ongoing removal activities and project close-out for removals in Europe, Africa, and Asia in the Gap Removal program. In addition, these balances will support the execution of a mock deployment exercise of the Mobile Plutonium Facility and the Mobile Uranium Facility to a location representing a tropical environment for the Emerging Threats Program. The

FY 2018 President's Budget Request included a reduction of new funds requested for the Nuclear Material Removal program taking into account the use of these uncosted balances.

The uncosted unencumbered balances for the Material Disposition Program ($27.0 million) will support the continuation of oxide production, surplus pit surveillance and monitoring, procurements of shipping containers for pit shipments, and program integration activities for the U.S. Plutonium disposition subprogram. In addition, these funds will continue to support the level of effort needed to down-blend surplus HEU to LEU in the U.S. HEU Disposition subprogram and will be used to alleviate the funding shortage due to the continuing decline of uranium market prices. This down-blending advances a number of important goals, including providing support for the tritium program.

Nonproliferation and Arms Control

As of the end of FY 2016, NPAC had costs plus encumbrances totaling $97.1 million, or 74.6% of its total FY 2016 available funds; the remaining $33.1 million in uncosted unencumbered balances (25.4% of available FY 2016 funds) exceeded the DOE threshold by $15.8 million. The $33.1 million in FY 2016 uncosted unencumbered balances are due primarily to the following factors: Continuing Resolution with consequent late receipt of funding (e.g., a congressional plus-up of $3.5 million for Part 810 process improvements was only received six months into the fiscal year, which was too late to feasibly encumber and cost the funds); lower than anticipated number of cases submitted to the UN JCPOA Procurement Working Group requiring technical and end-user export control reviews; unavoidable delays originating from the host country for several safeguards and export control projects; the need to have funding in place at the national laboratories to support projects that will be performed during the last quarter of FY 2016 and the first quarter of FY 2017; and information technology security delays associated with continued implementation of the Part 810 electronic review system. All unencumbered balances are obligated to M&O contracts and assigned and planned for specific projects.

Table 4. Cost plus Encumbrance Status, End of Fiscal Year 2016

Cost + Commitment Status, End of Fiscal Year 2016		A	B	C	D B + C	E D / A	F A - D	G F / A
		Data						
Expense Type	Program	Costing Authority (Obligated Funds)	YTD Cost	Total Uncosted Encumbered Obligations	Current Costs + Encumbrances	Costed or Encumbered as a % of Costing Authority	Total Uncosted Unencumbered Obligations	Unencumbered as a % of Costing Authority
Operating								
	Elimination of Weapons Grade Plutonium Production	1,102,878	0	1,102,301	1,102,301	99.9%	577	0.1%
	Nonproliferation and International Security	-20,525	-20,525	0	-20,525	100.0%	-0	0.0%
	Russian Surplus Fissile Materials Disposition	901,300	112,945	540,166	653,110	72.5%	248,190	27.5%
	Global Threat Reduction Initiative	59,344,423	36,195,102	19,433,645	55,628,747	93.7%	3,715,676	6.3%
	Congressionally Directed Projects - Defense Nuclear Nonproliferation	23,161	0	23,161	23,161	100.0%	0	0.0%
	NN50 International Material Protection and Cooperation (IMPC)	579,687,809	230,548,925	152,242,403	382,791,327	66.0%	196,896,482	34.0%
	NN40 Nonproliferation and International Security (NIS)	52,834,062	43,847,401	5,023,709	48,871,110	92.5%	3,962,952	7.5%
	NN91 Highly Enriched Uranium (HEU) Reactor Conversion	119,124,618	85,317,711	25,221,249	110,538,959	92.8%	8,585,659	7.2%
	NN92 International Nuclear and Radiological Material Removal and Prc	148,492,679	61,595,418	72,470,867	134,066,285	90.3%	14,426,394	9.7%
	NN93 Domestic Radiological Material Removal and Protection	66,458,834	47,293,484	16,042,564	63,336,049	95.3%	3,122,786	4.7%
	NN20 Defense Nuclear Nonproliferation Research and Development (D	166,258,600	130,195,060	23,130,557	153,325,617	92.2%	12,932,983	7.8%
	NN60 Fissile Materials Disposition	137,628,338	96,579,393	27,263,405	123,842,798	90.0%	13,785,540	10.0%
	DN10 Global Material Security	431,558,883	110,274,286	139,625,896	249,900,182	57.9%	181,658,700	42.1%
	DN20 DNN Research and Development	411,215,603	299,833,003	41,916,051	341,749,054	83.1%	69,466,549	16.9%
	DN30 Material Management and Minimization	316,004,363	146,269,371	82,328,862	228,598,233	72.3%	87,406,130	27.7%
	DN40 Nonproliferation and Arms Control	130,167,794	81,223,064	15,848,335	97,071,399	74.6%	33,096,395	25.4%
	DN80 Legacy Contractor Pensions	94,617,000	94,617,000	0	94,617,000	100.0%	0	0.0%
Operating Total		2,715,399,821	1,463,881,637	622,213,170	2,086,094,808	76.8%	629,305,013	23.2%
Construction								
	NN62 U.S. Surplus Fissile Materials Disposition	206,249,317	201,371,407	4,877,910	206,249,317	100.0%	0	0.0%
	NN60 Fissile Materials Disposition	25,575,541	23,943,946	-0	23,943,946	93.6%	1,631,595	6.4%
	DP09 Infrastructure and Operations (formerly RTBF)	22,918	0	22,918	22,918	100.0%	-0	0.0%
	DN30 Material Management and Minimization	340,000,000	140,494,938	194,501,409	334,996,348	98.5%	5,003,652	1.5%
Construction Total		571,847,776	365,810,291	199,402,238	565,212,529	98.8%	6,635,247	1.2%
Grand Total		3,287,247,597	1,829,691,928	821,615,408	2,651,307,336	80.7%	635,940,260	19.3%

Appendix G
Coordination within DOE and the U.S. Interagency

With the largest global nuclear security program in the U.S. Government, DOE/NNSA plays a primary role in implementing the U.S. nuclear nonproliferation agenda. DOE/NNSA coordinates closely with other elements of DOE, especially the Office of Environmental Management, Office of Nuclear Energy, and Office of Science.

As part of the whole-of-government policy development progress, DOE/NNSA also actively participates in White House-led interagency policy meetings (at all levels) on nuclear nonproliferation, counterterrorism, and emergency response, which are routinely held to develop consistent interagency policy positions and implementation strategies. DOE/NNSA also works in partnership with other U.S. Government agencies involved in nuclear nonproliferation and nuclear counterterrorism, especially DOS (to include receiving some funding for foreign capacity-building efforts) and DOD. Key DOS programs in this area are located in the Bureau of International Security and Nonproliferation and include the Nonproliferation and Disarmament Fund as well as the Offices of Cooperative Threat Reduction, Counterproliferation Initiatives, Export Control Cooperation, and WMD Terrorism. At DOD, programs in this area are primarily located in DTRA and include the Global Nuclear Security Program and Proliferation Prevention Program. Other agencies that work closely with DOE/NNSA on nuclear nonproliferation and nuclear counterterrorism include DHS, DOJ, and the NRC.

DOE/NNSA nuclear and radiological threat reduction activities that are coordinated with other offices within DOE and other federal agencies include:

- Radiological source disposal activities (coordinated with DOE Office of Environmental Management, which maintains disposal facilities that are used for certain types of radioactive sources);
- Nuclear Smuggling Detection and Deterrence activities (coordinated with DOS, FBI, and DHS);
- Research and development for nuclear detonation detection (coordinated with DOD, DOS, FBI, DHS, and other government agencies);
- Proliferation detection research and development activities (coordinated with DHS, DOS, DOD, DOE Office of Nuclear Energy, NRC, and other government agencies);
- Nuclear material removal disposition activities (coordinated with DOE Office of Environmental Management, which maintains infrastructure for the receipt, storage, and disposition of nuclear material);
- Reactor conversion and some nuclear material removal and transportation activities within the United States (coordinated with the NRC, which is responsible for licensing some of the converted reactors for operation and helping ensure the safe transport of nuclear materials within the United States);

- Activities to establish reliable supplies of the medical isotope Mo-99 produced without HEU (coordinated with DOS, NRC, and the Department of Health and Human Services [HHS]);
- Negotiating and implementing the U.S.-Russia PMDA (coordinated with DOS);
- Export control outreach and training activities (coordinated with DOS, DHS, and Department of Commerce [DOC]);
- Reviewing requests for authorization to transfer unclassified nuclear technology (pursuant to Part 810 of Title 10, CFR) and assisting with foreign atomic energy activities (coordinated with relevant DOE/NNSA offices and with DOS, DOD, NRC, DOC, and for certain cases the Office of the Director of National Intelligence, all of which play a role in reviewing these requests as per statutory requirements);
- Negotiating agreements for civil nuclear cooperation with foreign countries pursuant to Section 123 of the U.S. Atomic Energy Act (coordinated with all relevant DOE/NNSA offices and with DOS and NRC; DOE provides technical assistance on the negotiations, while DOS leads the negotiations and NRC provides concurrence);
- Management of access, dissemination, and use of IND information (coordinated with DOE Office of Classification, DOD, DOJ, DHS, DOS, NRC, and the U.S. Intelligence Community);
- Domestic nuclear forensic activities (coordinated with DHS, which manages the National Technical Nuclear Forensics Center);
- International outreach on nuclear forensic activities (coordinated with DOS);
- Domestic and international counterterrorism training activities (coordinated with the FBI, which collaborates with DOE/NNSA to administer these trainings);
- Capabilities for radiological environmental monitoring and assessment in the event of a nuclear or radiological incident (coordinated with DOD, EPA, HHS, and other federal agencies, which collaborate through the Federal Radiological Monitoring and Assessment Center);
- Responding to nuclear or radiological incidents (coordinated with the FBI, which leads the federal response to such incidents domestically; DOD, which leads the response to such incidents abroad; and DOS, which has the overall responsibility for the U.S. response to international terrorist events); and
- Capabilities to respond to accidents or incidents involving U.S. nuclear weapons (coordinated with DOD).

In addition to coordinating specific programs and activities, DOE/NNSA also works with other agencies to ensure effective overall coordination of nuclear and radiological threat reduction activities. DOE/NNSA and the Office of the Secretary of Defense hold Assistant Secretary-level coordination meetings regarding their cooperative nuclear nonproliferation activities and discuss areas where DOE/NNSA and DOD program strengths and unique capabilities may complement each other. A similarly focused coordination forum was created among DOS, DOD, and DOE to "map" their nuclear nonproliferation program plans in specific foreign countries to better coordinate the three departments' activities. In addition, DOE/NNSA's emergency management priorities (including response to nuclear proliferation and terrorist threats) are informed by, and aligned with, national security priorities as defined by counterterrorism and incident management lead agencies. These national security priorities include interagency strategic and operational plans developed by the FBI, FEMA, DOS, and DOD.

Appendix H
Glossary

Comprehensive Nuclear-Test-Ban Treaty (CTBT): A multilateral treaty that bans nuclear explosions by states party to the treaty, in any environment (on the Earth's surface, in the atmosphere, underwater and underground). CTBT was negotiated in Geneva between 1994 and 1996, and opened for signature by the UN General Assembly on September 24, 1996. The CTBT has been signed by 183 nations, but the treaty has not yet entered into force.

Fission: The process whereby the nucleus of a particular heavy element (such as uranium) splits into (generally) two nuclei of lighter elements, with the release of substantial energy.

Full-Time Equivalent (FTE): A unit that indicates the workload of an employed person, measured as the number of total hours worked divided by the maximum number of compensable hours in a work year.

Future Years Nuclear Security Program: A detailed description of the DOE/NNSA program elements (and associated projects and activities) for the fiscal year for which the annual budget is submitted and the four succeeding fiscal years.

High explosives: Materials that detonate, with the chemical reaction components propagating at supersonic speeds. High explosive materials are used in the main charge of a nuclear weapon to compress the fissile material and initiate the chain of events leading to nuclear yield.

High-performance computing: The use of supercomputers and parallel processing techniques with multiple computers to perform computational tasks.

Highly Enriched Uranium (HEU): Uranium material that has a 20 percent or higher concentration of the fissionable isotope U-235.

Joint Comprehensive Plan of Action (JCPOA): A multilateral framework between the Islamic Republic of Iran and China, France, Germany, the Russian Federation, the United Kingdom, the United States, and the European Union, committing the parties to a series of specific actions, as well as monitoring and verification measures, to ensure that Iran's nuclear program is exclusively peaceful. The JCPOA was signed on July 14, 2015; reached Adoption Day on October 18, 2015; and reached Implementation Day on January 16, 2016.

Limited Nuclear Test Ban Treaty (LTBT): Officially titled the *Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water*, this treaty was signed on August 5, 1963, by the United States, the United Kingdom, and the Union of Soviet Socialist Republics (USSR), and entered into force on October 10, 1963. The LTBT prohibits nuclear weapons tests "or any other nuclear explosion" in the atmosphere, in outer space, and under water. While not banning underground nuclear tests, the treaty does prohibit such nuclear explosions if they cause radioactive debris to be spread outside of the country's territorial boundaries. The LTBT is open to all states, and most of the countries of the world are parties to it (among some of the non-signatories are France, the Democratic People's Republic of Korea, and the People's Republic of China).

Low-Enriched Uranium (LEU): Uranium material that has a less than 20 percent concentration of the fissionable isotope U-235.

Materials Testing Reactor: a type of nuclear research reactor designed to allow testing of materials in high-intensity radiation fields.

Miniature Neutron Source Reactor: A type of low-power (~30kW) nuclear research reactor, used primarily for neutron activation analysis, education, and training. These reactors have cores consisting of about 1 kg of HEU, enriched to 90 percent or greater.

Molybdenum-99 (Mo-99): A radio-isotope primarily produced through civil nuclear processes (such as in nuclear research reactors) and widely used in medical applications.

Nuclear Detonation: An explosion caused by an uncontrolled release of energy produced by a nuclear fission or a nuclear fusion reaction.

Nuclear Nonproliferation Treaty (NPT): Officially titled the *Treaty on the Non-proliferation of Nuclear Weapons*, this treaty is the cornerstone of the global nuclear nonproliferation regime, which ensures the peaceful and beneficial use of nuclear technology and knowledge while preventing the spread of nuclear weapons. The NPT entered into force in 1970, and 190 states have subscribed. The treaty covers three mutually reinforcing pillars—nuclear disarmament, nuclear nonproliferation, and peaceful uses of nuclear energy.

Nuclear Security Enterprise: The physical infrastructure, technology, and human capital at the U.S. national security laboratories, the nuclear weapons production facilities, and the Nevada National Security Site.

Nuclear weapons production facility: A term referring to the Kansas City National Security Campus (Kansas City, MO), the Pantex Plant (Amarillo, TX), the Y-12 National Security Complex (Oak Ridge, TN), or Savannah River Site (Aiken, SC). The term can also refer to the Los Alamos National Laboratory (Los Alamos, NM) and the Sandia National Laboratories (Albuquerque, NM) with respect to some specific weapons production activities.

Pit: The critical core component of a nuclear weapon that contains fissile material.

Special Nuclear Material (SNM): Specially-controlled nuclear material, defined in the Atomic Energy Act of 1954 as plutonium, uranium-233, and uranium enriched in the isotopes uranium-233 or uranium-235.

Strategic Arms Reduction Treaty (START): Officially titled the *Treaty between the United States of America and the Union of Soviet Socialist Republics on the Reduction and Limitation of Strategic Offensive Arms*, this treaty was signed by the United States and the USSR on July 31, 1991, and entered into force on December 5, 1994. After the 1992 dissolution of the USSR, the Russian Federation succeeded to the USSR's obligations. The treaty called for both sides to mutually reduce their deployed strategic nuclear warheads and delivery systems to treaty-defined ceilings. The START treaty expired December 5, 2009. The replacement New START treaty, which further lowered the allowable number of deployed warheads and delivery systems, was signed by the United States and the Russian Federation on April 8, 2010, and entered into force on February 5, 2011.

Threshold Nuclear Test Ban Treaty (TTBT): Officially titled the *Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Underground Nuclear Weapon Tests*, was signed on July 3, 1974, by the United States and the USSR, and entered into force on December 11, 1990. It establishes a nuclear "threshold," by prohibiting tests having a yield exceeding 150 kilotons (equivalent to 150,000 tons of TNT).

TRIGA: This acronym, which stands for *Test, Research, Isotopes, General Atomics*, is given to a type of U.S.-designed nuclear research reactor that was widely exported to other countries for peaceful nuclear uses.

U.S.-Russia Plutonium Management and Disposition Agreement (PMDA): Officially, the *Agreement between the Government of the United States of America and the Government of the Russian Federation Concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes and Related Cooperation*, is a bilateral agreement, signed in 2000, that commits the United States and the Russian Federation to each dispose of no less than 34 MT of its surplus weapon-grade plutonium (subject to monitoring and inspection measures), with provision for the future disposal of additional amounts of weapon-grade plutonium that each side declares as excess to defense needs, and under the same or comparable transparency measures and other terms.

Warhead: The part of a missile, projectile, torpedo, rocket, or other munitions that contains either the nuclear or thermonuclear system (in the case of a nuclear warhead).

Weapons-Usable Nuclear Material (WUNM): Specific types of fissionable nuclear material, such as separated plutonium and HEU, which can be used to fuel a nuclear warhead.

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A Report to Congress

Prevent, Counter, and Respond—A Strategic Plan to Reduce Global Nuclear Threats (FY 2018–FY 2022)

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