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Introduction

Good morning Chairman Carper, Ranking Member Coburn, and distinguished members of the Committee. Thank you for the opportunity to testify before you today in recognition of the ten-year anniversary of the Department of Homeland Security (DHS) Science and Technology Directorate (S&T). During my tenure, the Directorate has built on congressional direction; the leadership of the two Under Secretaries who preceded me, Dr. Charles McQueary and Rear Admiral Jay Cohen; and on the talent and dedication of S&T staff to create a research and development (R&D) organization suited to meeting current and future demands of homeland security missions.

My testimony will describe why the development and adoption of new technologies are critical to meeting current and future demands of homeland security missions; how S&T knowledge products, technical analysis, laboratories, and university-based Centers of Excellence contribute to the effectiveness and efficiency of DHS operations; and how S&T is improving the capabilities and safety of first responders.

I will also describe how S&T has restructured its R&D processes to focus on high- impact projects that are rapidly transitioned to use in the field and that deliver a high return on investment for the American taxpayer.

Our progress toward these ends has benefited greatly from building strong partnerships with DHS Components and first responder communities and by leveraging R&D investments made by other federal agencies, universities, the private sector, and international partners. S&T has also expanded the application of our engineers' and scientists' technical expertise beyond technology development to include the analysis of operational problems, the instillation of systems-based solutions, and assistance with DHS acquisition processes.

Science and technology are essential to achieving DHS missions and to gaining operational efficiencies

DHS confronts a global landscape in which technology is both a key driver of evolving threats and an essential source of solutions to these threats. The tide of history has brought us, in the 21st century, to a hyper-connected world where science and technology are pursued and produced on a global scale with ever more powerful tools becoming accessible to nations, groups, and individuals. The United States faces determined and adaptive adversaries who will take full advantage of all the tools available to achieve their ends.

For example, cell phones are both an essential tool for economic development as well as an invaluable aid to recruitment, financing, and planning of terrorist operations. A cell phone costing approximately $400 today matches the computing power of the fastest $5 million supercomputer in 1975.[1] The Internet, which an additional two billion people will access by 2025,[2] is a driver of the modern economy, the medium of choice for distributing recipes for making improvised explosive devices (IEDs), and the source of cybersecurity attacks that the Defense Science Board has called an "existential" threat to national security.[3] Revolutionary advances in the biosciences, many of which are not yet translated into products, are expected to have social and economic consequences that dwarf the impacts of information technology. Thankfully, malevolent uses of biology have been limited, but more than a decade has passed since the Defense Science Board noted that "there are no technical barriers to groups or individuals creating a powerful bioweapon."[4]

Over the past three years alone, we have witnessed several highly complex and consequential disasters ranging from the Deepwater Horizon explosion and subsequent oil spill, to the Fukushima Daiichi nuclear disaster and Super Storm Sandy. Predictions point to the increasing likelihood of these types of events.[5] Our nation must improve its capacity to predict, prevent, and rapidly respond to and recover from such catastrophes – and science and technology will be essential to addressing these needs. The S&T Directorate is well positioned to be a source for solutions to these challenges.

Technology and analytical capability are the tools which will make it possible to meet growing demands most cost effectively. They are the key to doing more with less. Lastly, the Department faces increasing mission demands that will quickly outpace available resources. Air travel to the U.S. increased 12% from 2009 to 2012 and is projected to grow at 5% each year over the next five years.[6] Currently, 11.6 million containers come into our ports and are screened each year; DHS estimates that this volume will grow up to 3% per year over the next 5 years.

Mission of the DHS S&T Directorate is broad, varied, and serves many partners

The mission of DHS S&T is to s*trengthen America's security and resiliency by providing knowledge products and innovative technology solutions for the Homeland Security Enterprise.* Congress created the S&T Directorate under the Homeland Security Act of 2002, to among other things "[conduct] basic and applied research, development, demonstration, testing and evaluation activities relevant to any or all elements of the Department."[7] S&T also has a statutory

[1] James Manyika et al., *Disruptive Technologies: Advances that will transform life, business, and the global economy* (McKinsey Global Institute, May 2013).
[2] Ibid.
[3] Defense Science Board, *Resilient Military Systems and the Advanced Cyber Threat* (June 2001).
[4] Defense Science Board, *Biological Defense* (June 2001).
[5] Adam B. Smith and Richard W. Katz, "U.S. Billion-dollar Weather and Climate Disasters: Data Sources, Trends, Accuracy, and Biases," *Natural Hazards* 67, no. 2 (June 2013).
[6] Department of Commerce, "U.S. Commerce Department Forecasts Growth in International Travel to the United States Through 2016," http://www.commerce.gov/news/press-releases/2012/04/23/us-commerce-department-forecasts-growth-international-travel-united-s (April 29, 2012).
[7] Sec. 302(4) of Public Law 107-296 (codified at 6 U.S.C. § 182(4)).

responsibility for establishing a system for transferring homeland security developments or technologies to Federal, State, local governments, and private sector entities.

In the past decade, S&T has undergone many changes and continues to evolve. The extraordinary breadth and diversity of DHS's missions requires S&T to address a wide range of programs including DHS Components' near-term needs for new operational capabilities and improved operational effectiveness, efficiency, and safety. S&T also has responsibilities related to understanding and creating solutions to biological and chemical threats, and to conducting the R&D required to meet homeland cybersecurity needs. While DHS S&T's work is often identified with technology development, equally important are the Directorate's contributions to homeland security in the form of analyses or "knowledge products." These include analyses of alternative technology options; assessments of complex issues such as the relative risk of different chemical, biological, radiological and nuclear threats; operational testing and evaluation of technologies proposed for acquisition; detailed technical characterization of potential biological threat organisms to support both human and agricultural biodefense; and the creation of consensus standards that enable cost-effective progress across many fields. S&T also manages five national laboratories that provide unique homeland and national security capabilities and has direct access to the Department of Energy's extensive national laboratory system. In addition, the Directorate's capacity to engage R&D activities worldwide is greatly augmented by S&T's nine university-based Centers of Excellence (COEs) and 13 bilateral international agreements.

In order to meet the broad scope of our mission, S&T has built a highly trained and technically-proficient staff that is DHS's core source of science, engineering, and analytical expertise. To utilize our staff and budget for maximum impact, we have focused our energies on efforts that have a direct and demonstrable link to improving the efficiency, effectiveness, and safety of DHS's operational missions and enhancing the safety, interoperability, and communications capabilities of the first responder community. S&T's contributions to the Department and the Homeland Security Enterprise (HSE) fall into four general categories:

- *New capabilities and knowledge products* – S&T creates new technological capabilities that address DHS operational needs or are necessary to address evolving homeland security threats.
- *Process enhancements and efficiencies* – S&T conducts systems-based analysis to provide streamlined, resource-saving process improvements to existing operations.
- *Acquisition support* – The Department achieves more effective and efficient operations and avoids costly acquisition failures and delays by leveraging S&T's technical expertise to improve project management, operational analysis, and acquisition management.
- *Understanding of homeland security risks and opportunities* – S&T's relationships across DHS and the HSE contribute to strategic understanding of existing and emerging threats as well as opportunities for collaboration across departmental, interagency, and state/local boundaries.

S&T's R&D strategy emphasizes high impact deliverables, rapid transition of products to use in the field, and a high return on investment

Since 2010, S&T has pursued an R&D strategy designed to meet the urgent operational needs of DHS Components and first responders as well as Congress' expressed interest that S&T deliver meaningful products more rapidly than the typical decades-long R&D cycle. In addition, S&T's R&D strategy must take account of the wide spectrum of DHS missions and make the best use of S&T's limited resources. To satisfy these requirements, we have re-shaped our R&D efforts in three ways.

First, to ensure that our R&D projects reflect priority HSE needs and accommodate operational realities, S&T has forged strong partnerships with DHS components and first responder communities. Second, DHS's urgent operational needs require rapid technology development time frames. Our goal is to have programs deliver meaningful, useful new technologies to end users and operators within two to five years. To achieve this, S&T focuses on the late stages of R&D. We actively seek out technologies in which others have already invested, and we work to adapt, evolve, and apply these technologies to DHS needs. Third, we seek to maximize our return on investment in R&D by aggressively pursuing collaborations with other R&D organizations – federal agencies, universities, the private sector, and with foreign government partners.

Strong partnerships with DHS Components and first responders deliver results

Innovation and successful technology development requires a deep understanding of the problem to be solved; partnerships with users and operators are essential. In the past, many successful R&D prototypes developed by S&T did not transition because of failure of the project to reflect leaders' priorities, lack of plans for operational pilots, or failure to devise an appropriate and timely commercialization strategy or acquisition process for the technology. Today, all Homeland Security Advanced Research Projects Agency (HSARPA) R&D projects are grounded in "R&D strategies" that are developed in partnership with the users and which explicitly assess the increased capabilities, efficiencies, or safety to be gained should the project succeed. The R&D strategies are used by the Components to inform their acquisition planning timelines so that R&D programs can successfully transition into operational environments. We have learned from some of our most successful efforts, like the Apex projects,[8] that the better S&T understands the priorities, operational context, and constraints of the end users/operators, the greater the impact of our solutions.

Additionally, S&T's HSE and First Responders Group (FRG) have developed a sophisticated and layered approach for prioritizing the needs of first responders in the 73,000 state and local jurisdictions across the country. FRG works directly with first responder organizations to identify priority gaps in capabilities, establish operational requirements and standards, and ensure interoperability. Projects in FRG's three strategic thrust areas – increasing responder

[8] Apex projects are cross-cutting, multi-disciplinary efforts requested by DHS components that are high priority, high-value, and short turn-around in nature. They are intended to solve problems of strategic operational importance identified by a component leader. Each Apex project is codified with a signed charter agreement; the resulting S&T team is mirrored by an equally able, multidisciplinary team from the partner Component.

safety and effectiveness, enabling communications, and providing a common operating picture – result directly from close collaboration with the end users. Reflecting our focus on transition, we have worked to ensure that technologies developed in coordination with S&T are available to first responder communities nationwide; S&T's technologies are included in the Federal Emergency Management Agency's (FEMA's) Authorized Equipment List from which public safety agencies are authorized to purchase with their federal grant dollars. We have also collaborated with private sector companies to commercialize S&T products including multi-band radios, the Controlled Impact Rescue Tool, and the disposable Backboard Cover.

Robust partnerships with R&D collaborators contribute to high return on investment and rapid transition

The S&T strategy to maximize our return on investment and ensure a fast transition to use requires that we capitalize on any existing technology that could be adopted by or adapted to DHS purposes and that we leverage ongoing R&D efforts undertaken by other federal agencies, industry, universities, and by our international partners. This is a challenging task because of the vast and continuously shifting body of R&D unfolding in public and private sectors around the world. We term this initial environmental scan "technology foraging," and it has already had a large impact on S&T's ability to deliver a high return on investment.

One example of S&T adapting existing technology to DHS purposes addressed the U.S. Coast Guard's (USCG) need to track small vessels approaching a seaport. While most large vessels have communication, tracking devices, and identification tagging systems, many small vessels, including those that may be used for illicit activities do not. S&T, in partnership with the National Oceanic and Atmospheric Administration (NOAA) and DHS maritime components, developed software that uses currently deployed coastal NOAA weather radar systems to process the radar signal differently, enabling CBP and USCG to better identify and track small vessels.

Another example pertains to the Transportation Security Administration's (TSA) screening operations. In this case, S&T combined, adapted, and applied tens of millions of dollars' worth of basic science from the Defense Advanced Research Projects Agency (DARPA) and universities to the problem of detecting homemade explosives in the aviation environment. These investments in advanced data collection, compressive sensing (a mathematical means of extracting more information from signals such as X-ray diffraction), and in meta-materials for satellite communications were not originally funded by DHS or intended to impact DHS missions. However, S&T has applied these investments in basic research in ways which will result in more effective and less costly walkthrough checkpoint screening technology that dramatically enhances passenger experience as well as the effectiveness and efficiency (via lower false alarm rates, higher throughput, and lower costs of operations) of how TSA screens people, cargo, and luggage.

S&T actively forges partnerships with the private sector through a variety of mechanisms including Broad Agency Announcements, industry days, webinars, and our Small Business Innovation Research Program (SBIR). Since 2004, SBIR awards have produced 31 patents and 42 products on the market. We also have created unique public-private partnerships to share risk and accelerate technology development. For example, S&T initiated the Linking Oil and Gas

Industry to Improve Cybersecurity (LOGIIC) program, a unique public-private partnership that convenes five major oil and gas competitors to work with government on development and distribution of cybersecurity solutions that protect the industry's critical infrastructure. LOGIIC has been highly successful because industry participants partner in project concept development, share project costs, and then adopt solutions while making them available to the entire oil and gas industry. Completed projects to date address security issues in process control systems and application of white-listing technologies (the use of designated safe-to-run software). S&T often collaborates and shares costs with commercial entities on projects including first responder technologies, electric grid resilience, biodefense, and explosives detection among many areas.

S&T has also had a successful working relationship with In-Q-Tel (IQT)[9] to identify small, innovative start-up companies and invest in them to adapt their emerging commercial technologies. Every S&T dollar invested in IQT projects has leveraged almost $3 of additional U.S. Government agency funds and more than $10 of private capital. Thirteen S&T projects in diverse fields are underway with one investment already delivering portable, secure, wireless camera kits to the U.S. Secret Service. Another, which uses DNA markers to rapidly validate familial relationships and confirm identities, is expected to begin field trials with U.S. Citizenship and Immigration Services (USCIS) in FY 2014.

S&T has established robust international collaborations, administered through 13 bilateral agreements, which enable DHS to leverage funds, human capital, and R&D facilities in support of our mission. Our collaboration with international partners also substantively advances S&T's ability to address critical DHS missions. For example, S&T's international work includes collaborations with six international partners on cybersecurity efforts ranging from identity management to network resilience. We have also conducted joint homemade explosives testing with Israel, and we work with the United Kingdom on the detection of liquid explosives in aviation screening and on the development of rapid diagnostics for biodefense. The newest bilateral agreement, with the Netherlands, is already yielding valuable cooperation in areas of mutual benefit such as financial and fraudulent document forensics and cybersecurity.

Partnerships – with both S&T's end users/operators and with other R&D collaborators – are a cornerstone of how S&T does its work and have become the key to maximizing the S&T return on investment. Such collaborations allow S&T to identify high-priority problems and exercise a global reach across the dynamic spectrum of R&D efforts.

Ongoing review of the R&D portfolio ensures alignment with S&T strategy

S&T utilizes an annual portfolio review process to ensure that its projects reflect our emphasis on a high return on investment, high impact, and accelerated transition to use. The portfolio review process, originally developed by Fortune 500 companies and now widely deployed in the private sector and some Department of Defense (DoD) laboratories, uses a panel of experts to evaluate individual projects against specific scoring criteria selected by S&T that reflect our strategic goals and priorities. Evaluators include S&T leadership, outside experts, and

[9] IQT is the independent strategic investment firm that serves as a bridge between the U.S. Intelligence Community and start-up firms on the leading edge of technological innovation. S&T joined IQT in 2010.

"customers" – senior officials from DHS Components and representatives from the first responder community.

Each project is treated as a discrete investment, and its risks and potential impacts are evaluated against the common scoring criteria. Because all projects are evaluated in a consistent manner, the results can be rolled together to develop an integrated view of the entire portfolio of investments. Essentially, the process provides a method for examining research investments across diverse fields and disciplines using a common language, which helps the organization develop a coherent view of both individual projects and the positioning and likely impact of the overall portfolio. The process is disciplined, repeatable, transparent, strategic, and focused on continuous improvement.

Over the course of three years, we have driven our R&D portfolio towards S&T's top priority of transitioning useful new technologies to use as rapidly and efficiently as possible. Accomplishing this has meant the culmination of our new philosophy for R&D: reduction of the technical risk by exploiting already or partially developed technologies; getting much closer to customers and involving them directly in project planning, execution, and resourcing; and building a stronger network of R&D collaborators. We have seen tangible results. Since 2010, S&T has raised the percent of projects benefiting from non-S&T funding from 12% to 55%. The percentage of projects deemed likely to transition in the near term has risen from 25% to 49%, and the percentage of investment targeting high-impact, high-feasibility outcomes has increased from 38% to 54%. Some might question why these proportions are not even higher. But research, even late-stage R&D, is always risky. The results of three years of portfolio review have repositioned S&T's R&D portfolio from "sub-optimal" to "benchmark."

Beyond R&D: Supporting DHS missions through operational analysis, acquisition support, and other non-traditional contributions

S&T's value to the Department and the HSE extends beyond technology development. Component support also includes acquisition support, requirements generation, test and evaluation, operational analysis, standards development, and other non-traditional efforts. Collectively, these additional avenues for the thoughtful application of analytical and scientific expertise expand the ways S&T delivers efficiencies and cost savings to the HSE.

Acquisition support: Helping the Department make prudent investments in effective technologies

S&T plays a critical role in overseeing the quality and suitability of DHS acquisitions through the Directorate's operational test and evaluation (OT&E) activities. By statute and DHS policy, S&T is responsible for establishing T&E policy and procedures for DHS Major Acquisitions[10] and providing independent OT&E oversight and assessment. The Director for Operational Test and Evaluation (DOT&E), serving as the principal T&E advisor to the Secretary and Component heads, ensures that programs that come before the Acquisition Review Board (ARB) have been thoroughly and appropriately vetted via the evaluation of a system's technical performance, operational effectiveness, and suitability. This is the final step before the Department makes significant investment into production and fielding of acquired systems.

[10] Major Acquisition programs are those with total lifecycle cost estimates exceeding $1 billion.

To date, S&T has participated in more than 135 ARBs. Careful operational testing can prevent the Department from investing in ineffective technologies. For example, in an ongoing OT&E assessment of the USCG's new Fast Response Cutter, preliminary assessment identified critical reliability deficiencies in the main diesel engine; the manufacturer has since conducted a root cause analysis and completed an engine redesign to meet USCG mission requirements. Early detection of these types of issues can prevent significant and costly repairs and/or delays later in acquisition.

In the initial stages of acquisition, S&T has also helped components translate mission needs into testable requirements that ensure DHS procurements work as expected, deliver on time, and develop within budget. S&T continues to work with the Under Secretary of Management to bolster the "front end" of the Department's acquisition processes and procedures to avoid underperformance and misallocation of resources.

Operational analysis: A method for deploying resources more effectively

Another potentially powerful source of DHS cost savings and added capability comes from operational analytics – assessments of how work is done today and how operations might be adjusted to improve effectiveness, efficiency, and safety. These analyses form the basis for new technology development but can also be used to reconfigure a task. S&T works to make systems-based, operational analysis a key part of every project that we do and to help the DHS components adopt and routinely apply such tools to their work.

Standards development: A high impact method for promulgating technical rigor and consistency

Standards development is a difficult, seldom-noticed process that is critical to establishing technical rigor and consistent, cost-effective performance in technology development. Over the past decade, S&T has worked with the National Institute of Standards and Technology to fund the development of more than 130 technical standards, including 40 standards related to radiation detection recently adopted by DoD. Since 2001, responders have been called to address more than 30,000 suspicious packages involving powders. These incidents are often costly and disruptive; furthermore, the previous lack of uniform collection, processing, and analysis limited the admissibility of the substances as evidence to use against perpetrators. The S&T-led interagency effort to standardize sampling of suspected biothreat powders has bolstered the ability of investigators to locate and prosecute perpetrators of powder attacks and has increased the safety of responders during these incidents.

Supporting Anti-terrorism by Fostering Effective Technologies (SAFETY) Act program: Incentivizing industry to adopt anti-terrorism technologies and practices

At Congress' direction, S&T established and manages the SAFETY Act program. This unique program incentivizes the private sector's development and adoption of anti-terrorism preparedness/resiliency technologies and practices by offering liability protections and litigation management. Since the first application in 2003, the SAFETY Act program has approved more

than 600 applications from a wide range of companies, and in recent years, more than 50% of program applicants are from small businesses.

Over the past decade, the breadth of applications covered by the SAFETY Act has evolved to include sophisticated and layered security systems and practices for major facilities such as sporting venues and airports. S&T has taken special care to implement the program in a balanced, merit-based fashion—and the private sector recognizes its value. Recent feedback from a senior executive of an applicant highlights this notion, "[You] have a top notch program, one that has the necessary rigor to be viewed as truly credible, not just from a government perspective, but from industry as well." The SAFETY Act lowers risks for the private sector and encourages the adoption of critical technologies and practices that ensure a more resilient and better protected nation.

University-based Centers of Excellence leverage the ingenuity of academia

S&T's nine university-based Centers of Excellence (COEs) represent consortia of more than 275 colleges and universities in 47 states; each COE assembles leading faculty and graduate students to dedicate their intellect towards significant and diverse homeland security challenges such as border security, explosive threats, and resilience to natural hazards. Partnering with S&T and the components, the COEs pursue a mix of basic and applied research to deliver practical tools and analytic products which increase the effectiveness of components and save money. For instance, a storm surge and flood model developed by the Coastal Hazards Center (CHC) at the University of North Carolina-Chapel Hill now informs USCG and FEMA operational decisions. During Hurricane Irene, CHC's analysis led the USCG to relocate a Command Center just before its primary location was damaged by the hurricane. During Hurricanes Isaac and Sandy, FEMA, the National Hurricane Center, and state emergency management agencies used the tool to precisely stage resources and accurately anticipate stress on flood control structures.

Another example is an analytical tool developed by the University of Southern California-based National Center for Risk and Economic Analysis of Terrorism Events (CREATE) to help law enforcement deploy assets such as patrols with maximum effectiveness. USCG has adopted this tool for its ports, waterways, and coastal security mission and has deployed the tool in Boston Harbor, Port of New York/New Jersey, and the Ports of Los Angeles and Long Beach. Based on the initial positive results of patrolling higher-priority targets both more frequently and less predictably without additional capital or operating costs, USCG plans to deploy the tool in ports nationwide over the next several years, as well as expand it to other types of port operations. The Federal Air Marshal Service and Los Angeles International Airport (LAX) have also used the tool and experienced similar success, with LAX saving $500,000 per month in overtime costs after implementing the technology. The COEs have become part of the fabric of DHS; they provide a unique value and are emblematic of how S&T delivers value to the Department in ways that go beyond technology development.

S&T manages laboratories to conduct critical national security work

S&T has five laboratories centered on critical homeland security missions. Each a national asset, the labs fill a unique niche by providing testing, analysis, and novel research that is not found elsewhere in the national laboratory system.

- *National Biodefense Analysis and Countermeasures Center (NBACC)* provides the Nation a 24x7 operational biodefense capability with fully accredited, state-of-the-art laboratories. It conducts experiments, with the capacity to conduct classified experiments, that address fundamental knowledge gaps in biodefense in addition to serving the Federal Bureau of Investigation with testing and analysis on suspected biothreat samples, including analyses of the recent ricin envelopes mailed to public officials. NBACC has contributed to more than 100 federal law enforcement cases.
- *Plum Island Animal Disease Center (PIADC)* has served as the frontline for research on foreign animal diseases that could devastate markets for livestock, meat, milk, and other animal products. Operated in partnership between the Department of Homeland Security and the U.S. Department of Agriculture, it is also the only laboratory in the country that can conduct initial diagnostic testing for foot-and-mouth disease (FMD). PIADC scientists were recently co-inventors with a private company for a patent on the first ever FMD vaccine that can be manufactured in the United States. Unlike other FMD vaccines, this vaccine is the first vaccine that can be safely manufactured on the U.S homeland. The National Bio- and Agro-Defense Facility (NBAF) – a high containment research laboratory dedicated to protecting the Nation's one-trillion dollar agricultural sector from emerging zoonoses and agro-terrorism – is slated to replace the aging PIADC and will be an essential facility for national security.
- *Transportation Security Laboratory (TSL)* has provided certification testing of more than 100 explosive detection systems platforms on behalf of TSA and industry utilizing its unique dual ISO 9001 and ISO 17025 accredited operational capabilities.
- *National Urban Security Transportation Laboratory (NUSTL)* directly supports first responders by conducting tests, evaluations, and assessments of technologies and systems—both in the lab and in operational settings. Leveraging its New York City location, NUSTL developed and deployed a radiation sensor network that will provide real-time data to incident managers to guide response decisions following a radiological or nuclear event.
- *Chemical Security Analysis Center (CSAC)* is best known for the development of the Chemical Terrorism Risk Assessment (CTRA), which is a comprehensive evaluation of the risks associated with domestic toxic chemical releases. The CTRA is extensively used by DHS components and many interagency partners as a customizable tool to analyze and prioritize chemical release risks and generate tailored assessments.

Selected Achievements of the S&T Directorate

Attached as an appendix is a brief description of some of S&T's work for DHS and the HSE. Collectively, these highlight S&T's contributions through delivery of new capabilities, increases to efficiency and effectiveness, and support to first responders. Additional information on these and other projects can be provided upon request.

Conclusion

Scientific research and technology development are a fundamental means of enabling DHS to "do more with less." S&T's work has clearly demonstrated that new technologies, knowledge products, and systems-based operational analysis produced by the Directorate can significantly improve HSE mission effectiveness, operational efficiency, and safety. It is possible to conduct R&D in a manner that drives investments towards clear priorities, aids transparency and accountability, eliminates unwanted project redundancies and fragmentation, and effectively leverages other organizations' R&D investments.

There are, however, limitations to S&T's current strategies. Because it is not possible to address all of the highest priority R&D needs across DHS components and first responder communities, the Directorate is, to some degree, opportunistic in its choice of projects. Also, S&T has responsibilities in some areas – notably biosecurity and civilian cybersecurity – which, to meet critical overarching national needs, extend beyond certain requirements of its DHS component customers or the first responder community. S&T has also found it difficult to "transition" successful R&D projects to use by private sector entities, such as those responsible for the bulk of the nation's critical infrastructure sectors. In the current economic environment, the private sector's embrace of added security or resiliency is dependent upon approval by corporate boards focused on thin profit margins.

Homeland security missions encompass some challenges that will require long-term R&D investments that are less likely to be made by the private sector. Certain problems in biosecurity, cybersecurity, protection of critical infrastructure, and catastrophic disaster response and recovery will require sustained, strategic, government investments that are beyond the responsibilities of S&T. The Directorate's current collaboration with the UK Home Office, a mutual effort to develop rapid diagnostic tests that might make a strategic difference in the event of bioattacks, is one example of collaboration among governments and might offer useful insight into how such big problems could be tackled.

Over the past ten years, S&T has been fortunate in its people, whose talent and dedication to the homeland security missions are the essential resource from which all else springs. To be successful, S&T must be a workplace that continues to attract such people. This will require reasonably predictable funding levels, the ability to recruit and retain specialized expertise as needed, and congressional and Departmental support of the S&T mission. It also requires affording the opportunity for S&T professionals to remain engaged with their professional communities and keep abreast of developments in their fields.

Solutions to most of the major challenges in homeland security will require the innovative application of science, technology, and analytics. During the past decade, the Directorate has created an organization with significant and growing ability to help DHS and the HSE achieve their missions more effectively, efficiently, and safely. This progress is due to the hard work of S&T's people, to our deepening understanding of the complex problems confronting our operational partners and first responders, and to the Directorate's increasing capacity to identify and make use of innovation from all corners of the globe and all sectors of society. I am honored to lead the DHS S&T Directorate and look forward to your questions.

APPENDIX A:
Selected Achievements of the S&T Directorate

New capabilities

Below are brief descriptions of some of the new capabilities that S&T has transitioned or is developing for its DHS and HSE partners. These descriptions are intended for illustrative purposes; additional information on these and other projects can be provided.

Domain Name System Security Extensions (DNSSEC) protocol

- *Problem:* Because of the open architecture of the Internet, it is possible for hackers to redirect users from websites they intend to visit onto a hacker's website where sensitive data such as bank information can be stolen.
- *Solution:* To help counteract malicious hijacking, S&T worked with international partners through the Internet Engineering Task Force (IETF) to develop the DNSSEC protocol, which safeguards the architecture that delivers Internet users to their intended websites.
- *Impact:* More than 30% of the top-level domains (including, .com, .org, .us, and .uk) utilize the protocol, and the Internet Corporation for Assigned Names and Numbers has mandated DNSSEC implementation for all new domain names, which continues to spur adoption of the protocol. S&T continues to advocate wider implementation to safeguard more users of the Internet.

Buried Tripwire

- *Problem:* Certain terrain and foliage-rich environments along the southern border are difficult to monitor with traditional line-of-sight radars and cameras. Above-ground sensors are also vulnerable to attack.
- *Solution:* The Buried Tripwire technology can follow land contours (no blind spots), accurately pinpoint the intrusion right at the entry point, and distinguish between vehicles, humans and wildlife.
- *Impact:* The tripwire data is integrated into the Southern Border CBP Command Center for operational use. It increases monitoring capability, significantly lowers false alarm rates, and costs 1/10 of the current fence design to implement.

Foot-and-Mouth Disease (FMD) vaccine

- *Problem:* A 2001 FMD outbreak in the United Kingdom caused $8 billion in losses and resulted in the culling of more than 10 million sheep and cattle. Since use of previous vaccines during an outbreak would make vaccinated and infected cattle indistinguishable under current diagnostic tests and result in greater delays to re-opening U.S. export markets, no previous FMD vaccines were usable in the United States, which has a $1 trillion agriculture industry.
- *Solution:* S&T worked with the Department of Agriculture (USDA) and industry to develop and patent the first successful FMD vaccine in more than 50 years and also the first FMD vaccine licensed for use in the United States.
- *Impact:* The vaccine is now being transitioned to manufacturing with an industry partner. During an FMD outbreak, the vaccine allows vaccinated animals to be distinguished from infected ones and to be placed back into production rather than culled, potentially reducing

the cost of an outbreak by billions of dollars due to millions of vaccinated animals being allowed to live.

TSA security checkpoint of the future

- *Problem:* Due to increasing air travel and evolving threats, there is a need to improve security, throughput, passenger experience, and operational efficiency at airport checkpoints.
- *Solution:* S&T is guiding development of walkthrough detection machines with integrated shoe screeners that will produce better images, process passengers more quickly, and cost a fifth the amount to produce and a quarter the amount to maintain compared to existing screening systems. Screening machines will be responsive to dynamic threat environments, allowing TSA to increase the sensitivity of its machines in real time in response to threats faced. These technologies are being developed by a consortium of industry, university, and government partners, with S&T leveraging $25M in DARPA-funded basic research on compressive sensing for this project.
- *Impact:* When next-generation machines are delivered and deployed, passenger experience will increase substantially. Passengers will pass through checkpoints more quickly and efficiently and will no longer have to remove their shoes. Detection sensitivity will be increased and false alarms will decrease.

Border Enforcement Analytics Program (BEAP)

- *Problem:* ICE investigators currently use multiple, disparate data sets to generate investigative leads related to export enforcement and counter-proliferation. The size and nature of these data require time- and cost-intensive human processing that would be more effectively handled by computers.
- *Solution:* S&T combines academic and operational knowledge to produce new "big data" solutions, under appropriate privacy and civil liberties controls, that make sense of a large amount of data and significantly augment investigative capability.
- *Impact:* In addition to new capabilities that will open the door to new sources for prosecution, early test results show that ICE will significantly improve the efficiency of investigations. For example, in a preliminary experimental environment, the BEAP system processed 166 million export records and identified 277 potential violations in 16 seconds. BEAP is also paving the way for "big data" solutions that will help other increase capability and save resources with other DHS Components and elsewhere in the HSE.

Resilient Electric Grid (REG)

- *Problem:* Because of limitations inherent to current technology in the electric grid, utilities must separate the grid into isolated subsections. This prevents rolling power failure but, especially in dense urban areas, also prevents power sharing during emergencies, prolongs power outages, and leads to slow restoration efforts with substantial costs.
- *Solution:* S&T partnered with industry to develop superconducting power cable that overcomes previous limitations and allows interconnection of power stations, meaning faster and more efficient restoration of power in emergencies.
- *Impact:* REG is currently in operational demonstration in Yonkers, NY, in collaboration with the Department of Energy and Consolidated Edison. S&T is also exploring a scaled up implementation with NSTAR in Boston, MA, to lower the cable's production costs and move towards wider implementation.

Increasing efficiency and effectiveness

Below are brief descriptions of some of the ways that S&T is saving money and otherwise increasing the efficiency and effectiveness of its DHS and HSE partners. These descriptions are intended for illustrative purposes; additional information on these and other projects can be provided.

Science and Technology Operational Research and Enhancement (Apex STORE)

- *Problem:* The Secret Service requested support delivering technology to bolster the efficiency and effectiveness of its remote Protective Mission, which includes responsibility for the safety of the President and Vice President, their families, visiting heads of foreign states, and other distinguished foreign visitors.
- *Solution:* In a comprehensive two-year project, S&T delivered ten technologies to the Secret Service. S&T also worked with the U.S. Secret Service to develop a rigorous analysis and acquisition process that can be utilized to help facilitate future procurement and deployment of new technology that can enhance Secret Service capabilities.
- *Impact:* S&T fundamentally shifted how it invests in the Secret Service and supports the deployment of needed capabilities. Secret Service has implemented several of the technologies and is scheduled to take delivery of more in the near future. One example is the Looxcie camera system, which is a lightweight, hand carried, self-contained surveillance system that enables agents to monitor secured spaces more efficiently than through the use of additional manpower alone. Looxcie also costs one third of the existing legacy surveillance system while providing more capability. Another example of the technology procured is the ARMOR system, a lightweight, portable ballistic shielding system. The ARMOR system is lighter and more modular than the legacy system, leading to decreased transportation costs and more rapid deployment in the field.

Standard Unified Modeling, Mapping Integration Toolkit (SUMMIT)

- *Problem:* Conducting disaster response exercises requires large support teams as well as costly and time-consuming production of realistic scenarios, guidebooks, manuals, and decision charts.
- *Solution:* SUMMIT is a software tool that eliminates large support teams and long waits for results through rapid, cost-effective verification and validation of response tactics, plans, and procedures that enables analysts, emergency planners, responders, and decision makers to seamlessly access integrated suites of modeling tools and data sources for planning, exercises, or operational response.
- *Impact:* FEMA adopted this tool and saves $2 million per National Level Exercise. SUMMIT is available to other federal, state, and local agencies and has been used to support exercises in the Naval Postgraduate School, Los Angeles County Emergency Medical Services, and Utah Department of Public Safety.

Mobile Surveillance System (MSS) upgrade

- *Problem:* CBP uses MSS units to help monitor the borders for illegal entry between Ports of Entry, but existing units have less than optimal sensor performance and agent tools.

- *Solution:* S&T and CBP jointly developed an upgraded unit with better sensor capabilities and updated agent tools and maps. The radar is less expensive but more capable, has a greatly reduced false alarm rate, can operate effectively in inclement weather, and has lower operation costs.
- *Impact:* The upgraded unit has been in operational use on the southwest border since August. Capable of searching a much wider area, it has enabled many apprehensions and outperformed legacy MSS units in diverse environments, including conditions where legacy units would have been inoperable.

Forward Operating Base (FOB) Power Efficiency

- *Problem:* CBP wishes to reduce fuel and fuel trucking costs for its 14 FOBs and reduce the risk of fuel spills on environmentally sensitive roads.
- *Solution:* S&T is working with CBP to field fuel efficient generators and modular solar panel systems which reduce the operating costs for the FOBs.
- *Impact:* A new fuel efficient generator system will be installed at a remote Arizona FOB in FY13 that will save an estimated $112K annually in diesel fuel and trucking costs. The fuel efficient generator will pay for itself in the first year it is deployed.

Checked Baggage

- *Problem:* False alarms in TSA checked baggage screening require baggage to be fully searched by TSA staff. Each percentage point reduction of false alarm rates improves TSA operational efficiency as well as passenger experience by requiring fewer secondary inspections and moving passengers through faster.
- *Solution:* In collaboration with DARPA and TSA, S&T is developing next generation x-ray systems that incorporate advanced measurement methods from DARPA's Knowledge Enhanced Compressive Measurement program. These systems have the potential to significantly lower the false alarm rate.
- *Impact:* These next generation x-ray systems are anticipated reduce TSA false alarm rates by at least 10% for checked baggage screening operations, which allows DHS to be more efficient and effective by reallocating staffing costs associated with clearing false alarms to other high priority missions.

Vehicle and Cargo Inspection System (VACIS) upgrade

- *Problem:* CBP scans for threat items such as drugs, currency, weapons, etc, at land ports of entry, Border Patrol checkpoints, airports, and other locations. The non-intrusive inspection equipment used for this mission is operating beyond its ten-year lifecycle, and its performance is degrading. CBP lacks funding for new X-ray systems.
- *Solution:* S&T developed an upgrade to existing VACIS equipment that significantly improves image quality without replacing the entire system. This upgrade will cost under $500K per system, substantially less than a new $3.5M system and resulting in nearly $300K savings per year in operation and maintenance.
- *Impact:* In addition to lower operation and maintenance costs, increased non-intrusive inspection capabilities will result in approximately 20% fewer manual inspections of cargo containers each year, an approximately $30M savings per year for CBP.

Value to first responders

Below are brief descriptions of some of the ways that S&T is fulfilling its statutory responsibility to increase the effectiveness, efficiency, and safety of the more than 60,000 local, state, tribal, and federal first responder agencies. These descriptions are intended for illustrative purposes; additional information on these and other projects can be provided.

Multi-Band Radio (MBR)

- *Problem:* Today's hand-held emergency response radios typically operate on a single band and cannot directly access other frequency bands. This means that most agencies cannot communicate with those outside of their jurisdiction—or even within their own jurisdictions, sometimes—if they operate on different radio bands.
- *Solution:* MBR provides emergency response agencies with the unprecedented capability to communicate on all public safety radio bands.
- *Impact:* S&T's efforts and work directly with industry spurred development of a robust commercial MBR market with competition from multiple vendors leading to more mature MBR products at lower cost to first responders. MBR is now equal in cost, size, and weight to existing high-end portable radios and is commercially available through three manufacturers. To date, MBR have been purchased by state and local responders in Dallas, TX, Phoenix, AZ, and Missouri as well as the U.S. Marine Corps, Department of Interior, and U.S. Capitol Police.

Controlled Impact Rescue Tool (CIRT)

- *Problem:* In some disaster areas, victims may be trapped in collapsed concrete buildings, but existing tools to reach and rescue these victims are time consuming and endanger the lives of trapped persons and operators during the rescue effort.
- *Solution:* S&T partnered with industry to develop a new breaching tool that is less destructive, faster, and more controlled and thus safer to trapped victims.
- *Impact:* CIRT is now commercially available to first responders through Raytheon. The tool breaches reinforced concrete walls 85% faster than alternative technology and at the same time gives first responders greater control and overall safety.

Virtual USA® (vUSA)

- *Problem:* In an emergency, responders must quickly and easily access relevant, reliable, and up-to-date information from multiple partners on power outages, road closures, traffic incidents, hospital and shelter statuses, weather, etc. The proliferation of proprietary emergency response technologies has decreased interoperability among information sharing systems.
- *Solution:* S&T worked with state and local emergency management agencies and other DHS Components to develop vUSA, which improves information sharing and collaboration at all levels of government, allows agencies to build on existing investments and maintain data ownership, and enhances resiliency and disaster response by strengthening partnerships.
- *Impact:* vUSA is part of the White House Open Government Initiative and was used to assist in regional response to the 2010 Deep Water Horizon oil spill, 2011 regional response to Midwest floods, 2012 California wildfires, and the 2013 Presidential Inauguration.

Finding Individuals for Disaster and Emergency Response (FINDER)

- *Problem:* First responders need the ability to rapidly assess whether there are living victims buried in rubble and other debris in the aftermath of a disaster.
- *Solution:* FINDER uses low-power radar to detect breathing and heartbeats of buried victims, even under several feet of rubble and building debris.
- *Impact:* FINDER will increase the efficiency and effectiveness of search and rescue teams by more quickly directing rescuers to where the victims are and greatly increasing victims' chance of survival.

Wildland Firefighter Advanced Personal Protection System

- *Problem:* Wildland firefighters carry significant amounts of equipment and often hike miles in hot, humid conditions to reach fire lines. Traditional gear is heavy and uncomfortable, and wildland firefighters suffer more heat stress injuries than burn injuries.
- *Solution:* S&T leveraged extensive research by the DoD on undergarments for in-theater personnel to develop new firefighting gear (including jacket, shirt, pants, underwear, and socks) that is lighter, more flexible, more breathable, and more effective against radiant heat.
- *Impact:* S&T is working closely with the California Department of Forestry and Fire Protection, California county and local fire agencies, and the U.S. Forest Service and delivered more than 1,000 prototype ensembles currently in pilot tests by Californian wildland firefighters.

Ambulance Patient Compartment Design Standards

- *Problem:* Research has shown that emergency medical services (EMS) personnel experience a fatality rate of 12.7 per 100,000 workers each year—three times the average national occupational rate.
- *Solution:* S&T partnered with the National Institute for Occupational Safety and Health (NIOSH), the National Institute for Standards and Technology (NIST), and representatives from the EMS and manufacturing communities to develop ambulance patient compartment design and safety standards that will safeguard both EMS personnel and ambulance patients.
- *Impact:* Joint S&T, NIOSH, and NIST Ambulance Safety and Design Guide will provide ambulance design manufacturing criteria as part of ambulance purchasing requirements.