DEPARTMENT OF DEFENSE AUTHORIZATION FOR APPROPRIATIONS FOR FISCAL YEAR 2014 AND THE FUTURE YEARS DEFENSE PROGRAM

THURSDAY, APRIL 18, 2013

U.S. SENATE,
SUBCOMMITTEE ON EMERGING
THREATS AND CAPABILITIES,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

THE ROLE OF THE DEPARTMENT OF DEFENSE SCIENCE AND TECHNOLOGY ENTERPRISE FOR INNOVATION AND AFFORDABILITY

The subcommittee met, pursuant to notice, at 2:30 p.m. in room SR–232A, Russell Senate Office Building, Senator Kay R. Hagan (chairman of the subcommittee) presiding.

Committee members present: Senators Hagan and Fischer.

Majority staff members present: Richard W. Fieldhouse, professional staff member; and Robie I. Samanta Roy, professional staff member.

Minority staff members present: Thomas W. Goffus, professional staff member; and Anthony J. Lazarski, professional staff member.

Staff assistants present: Jennifer R. Knowles and Kathleen A. Kulenkampff.

Committee members' assistants present: Jeff Fatora, assistant to Senator Nelson; Christopher Cannon, assistant to Senator Hagan; and Peter Schirtzinger, assistant to Senator Fischer.

OPENING STATEMENT OF SENATOR KAY R. HAGAN, CHAIRMAN

Senator HAGAN. We will bring to order the Emerging Threats and Capabilities Subcommittee.

Good afternoon. We meet today to receive testimony on the health and status of the Department of Defense (DOD) science and technology (S&T) enterprise and its contributions to developing innovative and affordable systems for the warfighter. This hearing will delve deeper into some of the important topics that we touched upon last year in our hearing on the health and status of the DOD laboratory enterprise.

Despite the significant budgetary pressures we are facing today, DOD should be given credit for trying to preserve, as much as possible, the investments in S&T. Nevertheless, these budgetary pres-

sures, along with the pending drawdown of our forces in combat overseas and the associated decrease in rapid fielding requirements and the new defense strategic guidance, all are forcing the S&T community to reevaluate the priorities.

Two key areas of significant concern to me are the Department's ability to recruit and retain the best and brightest for its S&T workforce—and I know I have spoken to some of you about this—especially daunting when you look at the sequestration environment that we are in today, and the timeliness and affordability of the new weapons systems.

In order to address and understand some of these complex issues and DOD's approach to them, we are pleased to have five expert witnesses with us today. Mr. Alan R. Shaffer is the Acting Assistant Secretary of Defense for Research and Engineering (R&E). I understand that is the second time for an extended period of time over the last 10 years, so thank you.

Dr. Arati Prabhakar is the Director of Defense Advanced Research Projects Agency, better known as DARPA. I understand this too is your second time serving at DARPA, the first as a program manager and the founding director of DARPA's Microelectronics Technology Office.

Ms. Mary J. Miller is the Deputy Assistant Secretary of the Army for Research and Technology, also in this position for the second time.

Ms. Mary E. Lacey is the Deputy Assistant Secretary of the Navy for Research, Development, Test and Evaluation (RDT&E). As I said, welcome back. You are the only witness on this panel to date who was at the hearing that we had last year.

Dr. David E. Walker is the Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering.

I thank all of you today for your service in the cause for our national security. We look forward to your testimony. In order for us to have adequate time to discuss a broad range of topics—and especially with five witnesses also—I ask that you keep your opening remarks to, hopefully, 2 minutes. We are going to include your full written statements in the hearing record.

Before we hear from our panel, I want to turn to my good friend, colleague, and ranking member, Senator Fischer, for any opening remarks she would care to make. Thank you.

STATEMENT OF SENATOR DEB FISCHER

Senator FISCHER. Thank you, Madam Chairman, and thank you all for being here today. I truly appreciate your taking the time to come here and go through this briefing with us and have a conversation about the important issues before us.

I appreciate the innovative structures our military employs to conduct cutting-edge research. In my State, the University of Nebraska has partnered with the U.S. Strategic Command to advance its mission to protect the United States from an attack by weapons of mass destruction. General Kehler has noted the clear value of this partnership.

As we prioritize our scarce defense resources, it is critical that we continue to invest in advanced research and potentially game-changing technologies. The American military is the most advanced

and effective fighting force in the world. We must sustain our investment in the next generation of technologies to maintain our technological superiority and stay ahead of these developing threats.

Of course, these investments must be made wisely. I am eager to hear from our witnesses on the steps they are taking to scrutinize their investments and, in particular, improve coordination and eliminate duplicative research.

The current fiscal environment also demands that defense funds be devoted toward warfighting missions and capabilities. Past years may have permitted the support of research that had only marginal benefit to DOD, but I believe it is critical that DOD's S&T funding have a strong and clear benefit to its core mission: fighting and winning wars. DOD simply cannot afford to foot the bill for projects that are more relevant to other departments and agencies.

This subcommittee has its work cut out for it. Shedding non-warfighting research while protecting investments that could unlock the next generation of battlefield technology will be a complex and difficult task. We need the help of these witnesses to thread that needle.

So, thank you so much for being here.

Thank you, Madam Chairman.

Senator HAGAN. Thank you, Ranking Member Fischer.

What I would like to do is—I have had two charts handed out and I just want everybody to look. My first question actually relates to these talks. Oh, I am sorry. I apologize. I am ready for these questions and I am already omitting your opening statements. [Laughter.]

We will pull back on that. I know, I like my charts. [Laughter.]

So, Dr. Shaffer, if you would start first, please.

STATEMENT OF MR. ALAN R. SHAFFER, ACTING ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

Mr. SHAFFER. Chairman Hagan, Ranking Member Fischer, I am pleased to represent the scientists and engineers of DOD, a group that conceives, develops, and matures systems early in the acquisition process. They work with multiple partners to provide the unmatched operational advantage employed by our Services' men and women.

By the way, we like the charts also. [Laughter.]

As we wind down in Afghanistan, the national security and budget environments are changing. We are heading into uncertainty. The fiscal year 2014 President's budget request for S&T is $12 billion, a nominal increase from 2013's $11.9 billion.

However, it is not possible to discuss the budget without addressing the impact of the sequester, which takes 9 percent from every single program in RDT&E. This reduction will delay or terminate some efforts. We will reduce awards. For instance, we will reduce university grants by roughly $200 million this year alone and potentially reduce the number of new Science, Mathematics, and Research for Transformation (SMART) scholarship for service program awardees this year to zero. Because of the way the sequester was implemented, we will be very limited in hiring new scientists

this year and for the coming several years. Each of these actions will have a negative long-term impact to DOD and to national security.

The President and the Secretary of Defense depend upon us to make key contributions to the defense of our Nation. S&T should do three things for national security. First, we should mitigate the current and emerging threats facing our Armed Forces and Nation. Second, we should build affordability and affordably enable our current and future weapons systems to operate. Third, we should develop technology surprise to prevent potential adversaries from threatening us. My written testimony highlights specific programs in each of these areas.

In summary, DOD's R&E program is faced with the same challenges as the rest of DOD and the Nation. But our people are performing.

We appreciate the support of Congress to let us continue to meet the national security needs of DOD and the Nation. Thank you.

[The prepared statement of Mr. Shaffer follows:]

PREPARED STATEMENT BY MR. ALAN R. SHAFFER

Madam Chairman, Ranking Member Fischer, members of the subcommittee, I am pleased to be here today on behalf of the scientists and engineers in the Department of Defense laboratories, as well as the professional systems engineers and developmental test and evaluation personnel who work to conceive, develop, and mature systems early in the acquisition process. There are over 100,000 scientists and engineers performing these functions. These professionals have worked together, along with our partners in industry, academia, other governmental agencies, and allied partners to develop the capabilities and systems that have provided the unmatched operational advantage employed by the men and women of our Army, Navy, Air Force, and Marines, as well as other deployed U.S. and allied personnel.

I also represent the Office of the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)). Within the Office of the Secretary of Defense (OSD), ASD(R&E) is responsible for oversight of Department-wide activity from concept to early acquisition. Our Science and Technology (S&T) portfolio includes Basic Research, Applied Research, and Advanced Technology Development. The Research and Engineering (R&E) portfolio includes these budget activities as well as Advanced Component Development and Prototypes (ACD&P). ACD&P covers the technology transition from laboratory to operational use, and investment for prototyping which includes systems engineering and early developmental test and evaluation. Taken as a whole, these functions define the technical boundaries and possibilities of programs early in the Department's acquisition process.

When we step back and look at the capabilities developed and delivered by the Department of Defense research and engineering programs during the wars in Iraq and Afghanistan, I would contend that the Nation has received a good return on investment. I will cite three examples of capabilities developed during the past decade that were developed and fielded from our ASD(R&E) programs.

- Foreign Comparative Test program identified and tested the first Mine Resistant Ambush Protected vehicle systems, vehicles that provide dramatically greater underbody protection for passengers.
- Quick Reaction Fund developed the Persistent Threat Detection System (PTDS) and Persistent Ground Surveillance System (PGSS) both of which are tethered aerostat systems that provide constant surveillance around our forward operating bases.
- Rapid Reaction Fund developed and produced the Jungle Advanced Under Dense Vegetation Imaging Technology (JAUDIT), a laser radar system that can map very high resolution topography and identify objects under canopy. The JAUDIT system transitioned to a major acquisition program of record in the Army; renamed Tactical Operational LIDAR (TACOP). As a next generation improvement to JAUDIT, TACOP is deployed operationally in Afghanistan today.

The Defense Advanced Research Projects Agency (DARPA) and the Services have also developed and fielded a myriad of capabilities for our warfighters. For instance:

- DARPA created and fielded a wide range of highly effective tools including the High Altitude LIDAR Operational Experiment (HALOE), a sensor that delivered three-dimensional views of the battle space to operational and intelligence users, and the Vehicle and Dismount Exploitation Radar (VADER), a radar pod that aided in the tracking of threat vehicles and adversary dismounted personnel.
- The Marine Corps Program Manager for Expeditionary Power deployed the Ground Renewable Expeditionary Energy System (GREENS), a portable hybrid photovoltaic/battery power system that contains stackable 1600-watt solar arrays and rechargeable batteries combined to provide 300 watts of continuous electricity while in remote locations—reducing the need for fuel resupply.
- The Air Force S&T program delivered Blue Devil Block 1, an intelligence, surveillance, and reconnaissance (ISR) asset. Blue Devil began as a response to satisfy multiple Joint Urgent Operational Needs (JUONs) and was delivered to theater in less than 280 days. It is the only ISR asset that integrates both wide and narrow field-of-view high definition day and night sensors. These technologies provide near-real-time information to troops while simultaneously providing forensic information to analysts. The Blue Devil ISR platform has now flown thousands of sorties and saved countless American, coalition, and civilian lives in Afghanistan.
- The Army's Clinical and Rehabilitative Medicine Research Program (CRMRP) made great strides in wound repair and organ/tissue regeneration. To date, ten hand transplants have been performed on six patients. CRMRP currently has burn repair technologies in clinical trials with industry partners to meet military needs.

These examples are only a few of the technologies we provide to the forces deployed in theater. These technologies have given our military unprecedented protection and situational awareness to address the counter-insurgency first we face today. The research and engineering community has performed remarkably to provide new and focused capabilities to our warfighter over the past decade and will continue to provide them into the future.

CHANGES IN SECURITY LANDSCAPE

Over the past decade, the Nation and Department have been at war. The Department is now entering a new strategic period and the budget reflects changes in our mission. The strategic situation was well summarized by President Obama in the forward to the Defense Strategy "Sustaining Global Leadership: Priorities for 21st Century Defense." On January 3, 2012, President Obama said in the forward to the strategy:

> "As we end today's wars and reshape our Armed Forces, we will ensure that our military is agile, flexible, and ready for the full range of contingencies. In particular, we will continue to invest in the capabilities critical to future success, including intelligence, surveillance, and reconnaissance; counterterrorism; countering weapons of mass destruction; operating in anti-access environments; and prevailing in all domains, including cyber."

On March 15, 2013, Secretary Hagel directed senior leaders to conduct a review to examine the choices that underlie the Department of Defense's strategy, force posture, investments, and institutional management. While Secretary Hagel has directed this review, the "Sustaining Global Leadership" document drove the development of the fiscal year 2014 President's budget request just transmitted to Congress. The current budget challenges are forcing a review of the strategy but the S&T investment is crafted to address the still valid strategic challenges.

Secretary Hagel addressed the National Defense University on April 3, 2013. In this address, he highlighted the need to invest in technology during periods of austerity. He said:

> "As the military grappled with incredible challenges to morale and readiness after Vietnam it also made the transition to an All-Volunteer Force and protected key investments in technologies like stealth, precision weapons, and platforms like the F–16 and Abrams tank. Even during the 1990s procurement holiday, we invested in satellite guidance and networking systems, as well as remotely piloted aircraft that have been game-changers during the last decade of war. The goal of the senior leadership of this Department today is to learn from the miscalculations and mistakes of the past drawdowns, and make the right decisions that will sustain our mili-

tary strength, advance our strategic interests, and protect our Nation well into the future."

While the future budget situation is uncertain, the emerging national security challenges are stressing the Department in ways that we have not seen in a number of years. These current challenges need to be dealt with, in spite of a declining budget. I will cite five emerging security challenges that the United States and our allies be prepared to address. They are:

- The instability in Syria, a state with weapons of mass destruction that could fall out of state control;
- The continued development by North Korea of its nuclear weapons and missile programs;
- The emergence of very sophisticated "anti-access, area-denial" capabilities in a number of nations that could prevent the freedom of movement and access of the United States and our allies;
- The emergence of sophisticated cyber exploitation and attack; and
- The existence and increase in sophistication of advanced electronic attack capabilities of some of our adversaries.

While there are other emerging security challenges, each of the five challenges listed have strong technical challenges that should be addressed by the entire S&T enterprise.

SCIENCE AND TECHNOLOGY OBJECTIVES

The guidance is clear; the President and the Secretary of Defense depend on the S&T community to make key contributions to the defense of our Nation. Those contributions can be summarized in the following three objectives:

1. Mitigate new and emerging capabilities that could degrade U.S. (and allied) capabilities
2. Affordably enable new or extended capabilities in existing military systems
3. Develop technology surprise through science and engineering applications to military problems

Each of these three objectives is important and is listed in order of priority. Collectively, the Services and Defense Agencies work together to address each of these objectives. The first objective is aligned with defense of the homeland. The second objective addressees DOD's need to make every system we own and buy more affordable. The final objective, after we ensure the defense of the homeland and the affordability of our current and future systems, is to develop new concepts and technologies that create technology surprise. Pursuing these objectives form the basis of a new strategy in response to the evolving security situation.

On April 19, 2011, then Secretary of Defense Gates approved seven S&T priority areas. These priorities are still valid, and support our emerging strategy. While each priority has elements for all of these objectives, three of the seven S&T priorities most strongly support mitigating emerging threats—Cyber, Electronic Warfare (EW), and Countering Weapons of Mass Destruction (C–WMD). One of the priorities, Engineered Resilient Systems (ERS), is directly aligned with affordability, and the final three focus on developing technology surprise—Autonomy, Data to Decisions, and Human Systems.

A key element of the S&T Defense enterprise are the Priority Steering Councils (PSCs) which are groups of Senior Executive Service members from each of the Services and Defense agencies with investments in a technical area who work together to develop an integrated plan for their areas. Each of the seven S&T priorities has a PSC. We will describe the groups in more detail later, but these PSCs are integrating programs in technical areas across the enterprise.

A final element of the emerging strategy is to develop a better integrated R&E program across the entire Department. The job of OSD is to coordinate, integrate, and if possible, optimize the total Department-wide program. The components do a good job developing Service-unique systems. We want OSD to focus on the technical areas where multiple components have a substantial investment and provide coordination, integration and if possible, optimization across the Department. These technical areas align with areas no one owns but everyone uses. This includes space, cyber space, the electromagnetic spectrum, communications, and other specialty areas like materials science.

Objective 1: Mitigation of Emerging Threat

For a number of reasons, we are seeing an increase in the type and complexity of foreign systems and capabilities that could threaten the Department's ability to perform its missions. Examples of the new threats include, but are not limited to,

cyber threats, advanced electronic warfare systems, counter-satellite systems, and proliferating short- and medium-range ballistic and cruise missiles. In addition, old threats, such as weapons of mass destruction (WMD), become more acute when tied to extremist terrorist groups. The R&E community must deal with all of these emerging threats. Many of the specific emerging concepts are classified, but we can make some general comments on how the Department is addressing the challenges. We will address several areas.

(a) Cyber

The National Cybersecurity Coordinator, Michael Daniel, explained,

> "The government's senior-most civilian, military, and intelligence professionals all agree that inadequate cybersecurity within this critical infrastructure poses a grave threat to the security of the United States. Most recently, we have seen an increased interest in targeting public and private critical infrastructure systems by actors who seek to threaten our national and economic security."

In 2011, we established the Cyber PSC to focus the Department's investment. The Cyber team is led by the Technical Director of the Air Force Research Laboratory in Rome, New York with representatives from the Naval Research Laboratory, U.S. Army Communications-Electronics Research, Development, and Engineering Center, the National Security Agency, and OASD(R&E). This PSC is attempting to integrate the investments of all three Services, DARPA, and others into an integrated program. Across the Department, we estimate the investment in Cyber related S&T to be roughly $500 million in fiscal year 2014.

The PSC has focused Cyber S&T investments into six areas:

- Foundations of Trust - Establishing foundational authentication, confidentiality, identity, attribution, and authorization services that support secure DOD operational use of cyberspace.
- Cyber Resilience - Having the ability to absorb damage and ensure continuity information technology in support of mission operations even in the face of successful and widespread cyber-attacks.
- Cyber Agility - Ensuring that systems can adapt and maneuver very rapidly in their configurations or location. By being a moving target in cyberspace, agile operations make successful attacks from our adversaries much more difficult.
- Assuring Effective Missions - Allowing commanders, decisionmakers, and operators to evaluate options, tradeoffs, and outcomes to enable the orchestration of cyber elements in support of kinetic and cyber missions.
- Cyber Modeling and Simulation - Developing M&S capabilities that are able to simulate the cyber environment in which the DOD operates and enables a more robust measurement, assessment and validation of cyber technologies.
- Embedded, Mobile, and Tactical - Focusing on unique cyber security challenges of the Department's weapons platforms and systems beyond wired networking and standard computing platforms.

I also want to highlight efforts that we are using to accelerate cyber as a science. The Cyber Measurement Campaign invests to develop new analytical methodologies, models, and experimental data sets to establish metrics to measure a system's state of security. Massachusetts Institute of Technology Lincoln Labs (MIT–LL) is the ASD(R&E) designated study lead for this cross-federally funded research and development center collaborative effort to start the campaign, determine its direction, and perform initial experiments in the areas of resiliency (Phase 1) and moving target technologies (Phase 2). Phase 1 goals were to demonstrate experiments to measure and quantify resiliency with mature research prototypes. Phase 2 is focused on moving target technologies, and will be evaluated during this year's Terminal Fury exercise at U.S. Pacific Command (PACOM).

(b) Space

As with Cyber, the last 5–10 years could be described as an era when the United States space constellation has become more vulnerable. Electronic jammers present challenges for U.S. global positioning, and communications satellites. Both the United States and China have demonstrated missiles against low-earth orbiting satellites. Other threat capabilities have left the U.S. in a position where we must better protect our space capabilities. Again, there are no easy answers to deliver capability, so we need S&T. In fiscal year 2014, the Department plans to invest approximately $550 million in Space S&T. While not all encompassing, our preliminary analysis shows three areas do need attention: precision navigation and timing

(PNT), enhanced communications, and space resiliency. The first two are areas where, with S&T, the United States can reduce dependence on our current space architecture; the third area will begin the process of providing a new architecture.

1. Enhancement of Precision Navigation and Timing

The first area of engagement by the Department includes numerous activities to enhance the robustness of PNT. Currently, PNT capabilities are delivered primarily through the Global Positioning System (GPS), a system vital to numerous missions, ranging from conducting precision guided weapon strikes to synchronizing our communications networks. In an anti-access/area (A2/AD) denial scenario, it is reasonable to assume an adversary will seek to degrade or deny our use of GPS. The GPS program of record is pursuing modernization to further improve the anti-jamming and secure access of the military GPS signals. These vital efforts must continue.

At the same time, the DOD S&T program is providing alternate means to provide PNT for our forces. For example, cross-Service efforts are in progress to develop next generation Inertial Measurement Units to reduce their inherent drift thereby increasing operational time and effectiveness in a GPS-denied environment. Army labs are pursing efforts in relative navigation that will enable a combat team to determine their position even if only one element of a team knows its actual position. DARPA and the Navy are leading efforts to reduce the size of atomic clocks to bring GPS-quality precision timing into smaller systems. Additionally, we've reinvigorated efforts using non-GPS external references like ground/terrain features, RF signals, and stars—each excelling for certain applications. These near- and far-term efforts are not intended to replace GPS. Instead they will provide robustness in environments where GPS-based capabilities are being degraded or denied either by environmental factors or adversary action.

2. Enhancement of Military Communications

Military operations depend on voice and data communications networks that have robust reliability that exceeds most civil communication infrastructures. Unfortunately, much like PNT, sophisticated adversaries could degrade our space-based communication networks. The S&T community is working to provide other options for secure communications to our operational forces. Robust, cyber-protected and adaptable networks are needed in all domains, as high-priority traffic travels in surface, air and space layers to achieve reliable connectivity.

To better understand assured communications, we have matured or initiated several efforts, including:

- The Battlefield Airborne Communications Network (BACN); is a Rapid Reaction Fund effort that has turned into an enduring podded capability to augment satellite communication, fielded in Afghanistan and headed to Pacific Command.
- The SpiderNet/Spectral Warrior program to enable spectrum awareness by network operators while we continue to assess the resiliency and control of space communications assets aimed at offering increased survivability and effective reactions within A2/AD conditions.

We are conducting a series of reviews with the Services to examine the need for alternative means, such as hosted payloads, new orbits, and layering of communications pathways across air and ground domains. One capability included in the fiscal year 2014 budget is the Asymmetric Broadband Command & Control (ABC2) demonstration, an Iridium-based 'leave-behind' prototype that should assist in portable polar coverage in areas that traditionally experience sporadic and unreliable communications.

3. Enhancement of Space Launch Responsiveness

Finally, our current space architecture is comprised mainly of large satellites that may be vulnerable as some nations have demonstrated the capability to shoot them down. Again the S&T program should provide options. Recent technology developments, such as high resolution, small imaging focal planes, micro-inertial control systems, miniaturized thrusters and software programmable telecommunications, provide opportunities for DOD to employ low-cost, small satellites, ranging in the 10s to 100s of kilograms. When coupled with low cost launch systems this could enable an entirely new space architecture.

We have invested in two Joint Capabilities Technology Demonstrations (JCTDs) to examine these concepts. The Soldier-Warfighter Operationally Responsive Deployer for Space (SWORDS) JCTD provides a low cost, quick and predictable launch system for the Combatant Commanders and is capable of responding to urgent requests for augmentation of imagery or communications support. The Kestrel Eye JCTD provides the capability to deploy multiple imaging satellites to provide near-real-time situational awareness to the ground component warfighter. The

major benefit of Kestrel Eye is the ability of the satellite to be tasked directly by the lowest echelons of command. This benefit is achievable since the satellite is expected to have a low per-unit cost (<$1.5 million) in production. With this low cost, sufficient numbers of satellites could be made and deployed to provide assured access, on-demand to the warfighter. Coupled together, these two JCTDs provide a glimpse of the future of affordable responsive space.

While constellations of small satellites cannot completely replace our need for the main-line Defense and Intelligence spacecraft, our ability to rapidly launch and, if necessary, quickly replenish constellations of small satellites to maintain essential warfighting capabilities could deter potential adversaries.

(c) Electronic Warfare/Electronic Protection

The third emergent threat area is electronic warfare (EW) and electronic protection (EP). Simply put, the convergent maturation of multiple technologies has resulted in significantly new EW capabilities. The technologies include:

- Digital electronics
- New microelectronics providing increasing bandwidth, reliability, and agility of sensing systems including radar
- Digital/analog converters
- Photonics

These technologies can, through direct adaptation, provide potential adversaries capabilities that, in some case, could present operational challenges to U.S. forces and systems. Such developments, combined with longer range stand-off weapons and sheer numbers of jammers and decoys, represent a substantially different challenge for our forces, which for decades have routinely enjoyed virtually uncontested dominance in the use of the electromagnetic spectrum. If left uncontested, this situation could result in circumstances that negate the value of some of our most expensive and sophisticated sensors and weapons.

As with cyber, the Department established the EW PSC, led by the Air Force with senior leaders from all the Services and OSD to guide and focus Departmental investments in EW. The EW PSC has been meeting to aggressively address the threats with a roadmap for coordinated development of EW capabilities. Within ASD(R&E) our Electronic Warfare and Countermeasures Office, in conjunction with the Research, Development and Acquisition (RDA) Task Force, initiated several efforts to regain U.S. dominance of the electromagnetic spectrum.

New emphasis is being placed on research and development to regain U.S. electronic component superiority to mature the next generation of electronic and photonic components with performance exceeding that of commercial off-the-shelf (COTS) devices and to demonstrate these components in EW systems. To augment a substantial on-going EW S&T investment, the Department launched a pilot effort in fiscal year 2013 to explore technologies that are essential to the superiority of future U.S. EW systems. EW S&T research, at the component and system techniques levels, is vital to the development of new, modern electronic attack and protection technologies for the future. Hand-in-hand with those key developments will be having the advanced testing equipment to facilitate the development of future EW systems.

Test capabilities should adapt to the reality of adversary sensors and weapons systems with advanced electronic components. In fiscal year 2014, the Department has increased investment by $480 million over the Future Years Defense Program to provide major upgrades of our testing facilities to include advanced radar sensors to represent the digitally reprogrammable systems our potential adversaries are fielding. Not only do we need to test against advanced sensors but also we anticipate enemy weapons systems will be networked with sophisticated command and control functions. Upgrades to our test facilities will provide our advanced platforms with the signal densities from multiple netted sensors that they would expect to encounter in combat. These upgrades are not exclusive to open air ranges, although, that represents a significant investment. We are upgrading laboratory and anechoic chamber capabilities to the point that we will be able to employ electronic attacks and EP in software in the lab with threat representations validated by the intelligence community. As testing progresses through the lab, to the chamber, and finally to open air testing, we will progressively insert hardware in the loop while maintaining consistency in the signal environment.

(d) Counter Weapons of Mass Destruction

The final PSC in the emerging threat area, C–WMD, is focused on advancing the Department's ability to locate, secure, monitor, tag, track, interdict, eliminate, and attribute WMD weapons and materials. In fiscal year 2014, the Department plans to invest approximately $87 million in C–WMD. This investment only represents the

funding aligned with finding loose fissile material. The Department recently concluded an interagency planning effort to define a robust S&T program to establish the science, technology base, and intellectual capabilities needed to support current and future C–WMD operations. Since 2011, the effort has been narrowly focused on finding and following nuclear materials. However, the products produced by the PSC to identify threat signatures and alternate ways of thinking about C–WMD, have broad applications across the nuclear, chemical and biological domains. The Defense Threat Reduction Agency (DTRA) is the principal research agency in this domain and has support from all of the Military Departments and several Defense Agencies in performing and supporting relevant foundational research. Because DTRA is also a combatant support command, there is strong connectivity between the technical and operational challenges for this important mission. The DOD S&T program coordinates and collaborates with critical stakeholders, including the National Nuclear Security Agency, the Department of Homeland Security, and the Department of Health and Human Services. We also work closely with international partners in areas of mutual interest.

The S&T support in C–WMD ranges from fundamental research in the physical and biological sciences to more applied research for mitigating the WMD threat. The latter includes technologies for actively countering WMD weapons, sensors and personnel protection for chemical, biological, radiological, and nuclear (CBRN) threats, modeling and simulation of WMD effects, and medical countermeasures against chemical and biological threats. DOD S&T also develops tools for use in reach-back response to chemical, biological, or nuclear hazards. Technically, S&T continues to improve our detection and advanced sensors, both active and passive, and novel combinations of acoustic, radio-frequency, optical, and infrared sensing that may provide definitive detection and characterization and network analysis.

Objective 2: Affordability Enables New or Extended Capabilities into Existing Military Systems

The second objective focuses on affordability, which includes affordability of new systems and their life-cycle upgrades, interoperability between existing platforms, and design and prototyping of new systems. All levels of leadership in the Department clearly understand the need to be thoughtful about each and every dollar we request and to carefully assess and justify the criticality of every item in our budget. As the Department shapes its future plan to reflect fiscal realities, it will continue to focus on efficiency and affordability in everything we do. Acutely aware of budget pressures, a key piece of our strategy is to make the most of our shrinking portfolio with the Better Buying Power Initiative. Our approach has been to maximize our investment dollars by improving design capabilities and making the transition of technologies to acquisition programs more effective and timely.

(a) Engineered Resilient Systems

One area where the Department has specifically focused attention on S&T to improve efficiency has been on the design process itself. As stated previously, one of our seven S&T priorities is ERS; an S&T objective that organizes work across the Department focused on rethinking the way we design and develop systems and to explore new concepts, tools, and processes to allow complex design to occur faster, smarter, and more cost-effectively.

The Department's investments in ERS form the bridge between S&T and future engineering and test capabilities that aim to make our warfighting systems more affordable and interoperable. In fiscal year 2014, the Department plans to invest roughly $470 million in ERS. The S&T investment in ERS is focused on infrastructure, information, design and decision support tools, and knowledge environments that:

- Increase the speed of system development
- Improve effectiveness of fielded systems
- Minimize lifecycle costs

S&T efforts include integrating physics-based models with acquisition, quantifying the effects of architecture changes on system cost and performance, and automating trade-space analyses. ERS will leverage Department investments in human systems and data to decisions (D2D) to improve knowledge management and training during the entire lifecycle. By 2022, the goal of ERS is to achieve:

- A 75 percent reduction in the time to complete systems by reducing rework;
- A 100-fold increase in the number of parameters and scenarios considered in setting requirements prior to Milestone A;
- Quantified adaptability to changing mission requirements; and
- Integrated producibility and lifecycle concepts across acquisition

The Director of the U.S. Army Engineer Research and Development Center leads the ERS initiative with support from all the components. The ERS lead monitors existing S&T programs, progress toward ERS goals, and identifies gaps in the S&T portfolio related to ERS.

(b) Systems Engineering InitiativeS

Within the office of ASD(R&E), DASD (Systems Engineering) and DASD (Developmental Testing and Evaluation) perform additional functions mandated by the Weapon Systems Acquisition Reform Act of 2009. Each of these offices has considerable influence on acquisition success by ensuring that large acquisitions programs are properly planned, include appropriate engineering efforts to map requirements into technical specifications, realize those specifications in product and sufficiently test those products throughout their development. Both of these offices have undertaken significant initiatives to address acquisition affordability by ensuring better technical planning even earlier in the acquisition lifecycle—by engaging programs at the pre-milestone A stage.

The ASD(R&E) Systems Engineering office has led the Department's implementation of development planning, increasing early acquisition program planning and enabling the Department to make more informed early investment decisions based on a better understanding of technical risks and opportunities. DASD(SE) established the Development Planning Working Group (DPWG) in fiscal year 2011, involving key requirements and acquisition stakeholders from across the Military Departments, OSD and the Joint Staff to ensure a common understanding and consistent implementation of development planning across the Department. The DPWG has been effective in developing clear guidance on early phase technical planning, providing sponsors and programs with a roadmap of how to better formulate and execute effective program plans from a program's beginning. With direct support to premajor defense acquisition program, DASD(SE) has helped establish programs with realistic requirements, shape technical strategies, and support a robust Analysis of Alternatives (AoA) process that assesses technical risks in areas such as reliability, maintainability, manufacturing, and schedule. DASD(SE) has worked directly with program offices to develop their Systems Engineering Plans, shape the Technology Development (TD) phase technical approach, and review the program's draft requirements, enabling informed requirements trade decisions that balance cost and performance and properly manage technical risks. By engaging programs early through development planning, DASD(SE) has helped to make the Department's senior leadership more informed about early acquisition investment decisions and more effective in planning and executing programs.

(c) Developmental Test and Evaluation Initiatives

The DASD(DT&E) office has initiated an effort, entitled "shift left" designed to engage acquisition programs earlier in the life cycle, thereby ensuring a better understanding of program technical risks and opportunities before major milestone decisions. The basic premise of "shift left" is to find and fix problems before entering production. This should save money. There are three key focus areas to the "shift left" concept: earlier mission context, earlier interoperability testing, and earlier cyber security testing. Improved DT&E moves beyond the traditional technical focus to include testing in the mission context to characterize capabilities and limitations. Robust DT&E should also include all of the elements of interoperability and cyber security testing that previously was not tested until late in the acquisition life cycle.

DASD(DT&E) will focus attention on these areas and work with the Program Manager, Chief Developmental Tester, and Lead DT&E Organization to address these issues when they assemble the Test and Evaluation Working Integrated Product Team (WIPT) and write the Test and Evaluation and Master Plan. In the areas of interoperability and cyber security, DASD(DT&E) is working with all stakeholders to insert needed testing early and define the right way to oversee these processes. It is important that we be clear in our intent: our objective is to establish processes to oversee the developmental testing activities that support certification, not oversee the certification process. Simply put, DASD(DT&E) is working hard to improve the Service developmental testing functions.

(d) Data Reuse

The final specific area I would like to highlight is enhancing affordability through data reuse, led by the Defense Technical Information Center (DTIC). DTIC has the responsibility to develop, coordinate, and enable a capability to store, reuse, and apply technical information, data, and knowledge. DTIC has made tremendous strides in the past several years to evolve from a library function to an information exchange function, and in so doing has increased their support of the entire DOD R&E program. In this role, DTIC fosters information exchanges, empowers

innovators with greater efficiency, effectiveness, and agility that supports accelerating the delivery of warfighting technology. The fiscal year 2014 budget request for DTIC is $56 million.

DTIC connects scientists, engineers, researchers and warfighters by enabling the R&E community to build on past work, collaborate on current challenges, avoid duplication of effort, accelerate fielding solutions at reduced costs, aid decision makers, and support management of the S&T Enterprise. DTIC registered 6,857 new users and supported 3,771 average monthly active users in 2012. These new and returning users have increased usage of DTIC collections by 20 percent.

Bringing together the mix of performers in the lab, operational, and acquisition communities can pose technical and cultural challenges. Colleagues are separated by geographical and organizational structures. DTIC's information sharing efforts extend beyond official reports, to include researcher provided insights, areas for questions and answers, industry capabilities, and communication of DOD strategies and opportunities to industry. DTIC works to break down barriers by providing tools to support organization-to-organization connections and person-to-person interactions. Tools like DOD Techipedia hold an online electronic encyclopedia of knowledge and provide a platform where organizations can share information on challenges and needs. The Acquisition, Technology and Logistics community uses DOD Techipedia to support management of Major Defense Acquisition Programs (MDAP). Another recently developed tool is called DOD TechSpace, a tool similar to Facebook, which allows teams to connect on work issues, share ideas, and link to experts.

To support our diverse stakeholder community, DTIC ensures appropriate users have easy access to relevant content while protecting sensitive data through information security, cyber security, and intellectual property safeguards. In support of the Better Buying Power initiative, DTIC develops tools to analyze and visualize Independent Research and Development (IR&D) investments for DOD decisionmakers to strategically invest scarce resources.

Objective 3: Development of New Capabilities (Technology Surprise)

While the Department's S&T program is mitigating emerging threats and striving for greater affordability, completing just these two objectives is not satisfactory by itself. If all we do is react, the Department does not lead change. A critical component in the Department's ability to develop new capabilities is its investment in a wide range of basic research and applied research in new areas that have the potential to transition into major new technologies and capabilities. DARPA lives in this space. Objective 3 tends to be mid- to long-term focus and includes areas like quantum sciences, synthetic biology, engineered nano-materials, and many others.

I will start with the Department's investment in basic research, move through three PSCs that are focused on new capabilities (autonomy, D2D and human systems), discuss a special area, medical science, and then close with a new effort, to be hosted at DTIC, to better provide for technology watch/horizon scanning of emerging technical areas.

(a) Basic Research

The Department's Basic Research program has a longstanding history of investing in multidisciplinary and transformative research by leading scientists and engineers. The strength of its program is its ability to invest in research areas that have been identified as a priority to the DOD. The fiscal year 2014 President's request of $2.2 billion with actual real growth compared to inflation, highlights the importance and strong investment that the DOD places in its basic research program. This investment supports literally hundreds of individual grants.

While the Department invests heavily in traditional basic research areas like chemistry and material sciences, the Department also actively examines and assesses the global scientific landscape to identify emerging scientific research areas that may develop into gamechanging technologies in the future. Some of these areas that we are focusing on for the future include:

- Synthetic Biology, where novel products in diverse areas such as biofuels, bio-sensors, vaccines, programmable devices, and high-strength materials.
- Quantum Information Science, whose applications might lead to new forms of secure communications, greater precision in the measurement of time and location, and simulation leading to development of new classes of materials.
- Cognitive Neuroscience, where increased understanding of brain function can inform researchers about human learning, decisionmaking, effective

training methods, and the effect of stress, sleep, and post-war trauma on our military personnel.

• Understanding Human and Social Behavior, which can further our understanding of how individuals, groups, and nations work to enhance strategic and tactical decision making, improve immersive training and mission rehearsal, and facilitate cross-cultural coalition building.

• Novel Engineered Materials, such as superconductors, metamaterials, plasmonics and spintronics, which can be designed to provide novel coatings, self-healing properties, energy efficiency, and improved detection and computational capability to existing materials.

• Nanoscience and Nanotechnology, where increased understanding of material properties at the nano-scale can open doors to new classes of electronics and sensors, chemical catalysts, high-strength materials, and energetic properties.

In fiscal year 2014, we are migrating the Historically Black Colleges and Universities and Minority Institution (HBCU/MI) program back to an OSD budget line, and re-categorizing the investment as basic research. The HBCU/MI research and education program strives to build the capacity of HBCU/MI to perform world-class research, as well as to involve students in that research to foster their interest in pursuing careers in science, technology, engineering, and mathematics (STEM) disciplines. As part of our administration of that program, we continually look for ways to increase the participation of HBCU/MI and ensure that we involve these institutions in activities of mutual benefit to them and DOD. Among our efforts during this past year was a very successful workshop where we brought together HBCU researchers from over 30 universities and their technical counterparts in the DOD research offices in a forum that allowed the researchers to talk about their research and understand DOD research priorities. We also seek to ensure that the research and education role of HBCU/MI is recognized as an integral part of the Department's larger research agenda by taking into account HBCU/MI viewpoints and capabilities as we develop initiatives and address challenges for the longer term. In fiscal year 2014 we plan to increase our HBCU/MI's investment to support the development of Centers of Excellence at HBCU/MI around cutting-edge research areas, such as cyber-security, autonomy, and D2D.

Since its inception in 1992, the DOD HBCU/MI program has funded over 750 research and education grant awards, including awards for investigator-initiated research and awards to acquire equipment and instrumentation. More than 160 HBCU/MIs received these awards, which totaled over $350M. The 150 funded HBCU/MI included 75 percent of the designated HBCUs (76 out of 103) and about 85 percent the Tribal Colleges and Universities (30 out 35), with most of the remaining awards going to Hispanic-Serving Institutions.

(b) Autonomy

Autonomous technologies enable DOD warfighting systems to function with greater independence from human interaction and with reduced response times in stressed environments. The true value of autonomy is not to provide a direct human replacement, but rather to extend and complement human capability with autonomous systems. The Department's fiscal year 2014 S&T investment in autonomy is approximately $300 million and focuses on developing systems that perform complex military missions in dynamic environments with the right balance of warfighter involvement. Such autonomous systems can extend warfighters reach via unlimited persistent capabilities, offer warfighters more options and flexibility to access hazardous environments, and react at speeds and scales beyond human capability.

To implement autonomous capabilities, the Department has established four technical autonomy focus areas: Human and Agent System Interaction and Collaboration (HASIC); Scalable Teaming of Autonomous Systems (STAS); Machine perception, Reasoning and Intelligence (MRI); and Test, Evaluation, Validation, and Verification (TEVV) and has developed a capability development roadmap for each area.

Additionally, the Department established the Autonomy Research Pilot Initiative (ARPI), an initiative that will facilitate a coordinated S&T program guided by feedback from operational experience and evolving mission requirements. This program engages multiple Department laboratories on an internal, inter-service competition of autonomy-related applied research topics conducted by government scientists and engineers. The ARPI source selections are ongoing for the work to be performed in fiscal year 2014–2016.

Through the ARPI, the Department will allocate approximately $15 million for up to 3 consecutive years, totaling up to $45 million. Advancement of technologies from investments in the four technical areas will result in autonomous systems that pro-

vide more capability to warfighters, lessen the cognitive load on operator/supervisors, and lower overall operational cost. In addition, these investments will facilitate harnessing the potential of autonomous systems and strengthening mission effectiveness while maintaining fiscal responsibility and optimizing interoperability across space, air, ground, and maritime domains.

(c) Data to Decisions

The second area to develop new capabilities is D2D which brings in elements of "big data," data analytics, graph theory, and other emerging concepts in the knowledge domain. The 2012 National Security Strategy states that "for the foreseeable future, the United States will continue to take an active approach to countering [threats] by monitoring the activities of non-state threats worldwide[.]" D2D seeks science and applications to reduce the time and manpower associated with the analysis of large data, leading to actionable data. In fiscal year 2014, the Department plans to invest approximately $535 million in D2D. Investments in this new research priority area provides tools and insight into the widely available data to discover patterns and trends, analyze potential outcomes, and prevent strategic surprise. As a cross-cutting and enabling priority area, the research foundations of mathematics, statistics, and computational methods within D2D area are relevant across many of the missions and business areas within the DOD to include intelligence, operations, logistics, and personnel and readiness.

For intelligence data, challenges persist in analyzing the increasing amount of information resulting from improved sensor performance and the widely available and relevant open source information to support analysis and decision making. With this abundance of data, the need to discover and identify patterns, such as threat signatures, in complex, incomplete, imprecise and potentially contradictory large data sets has become a critical issue in decisionmaking processes within the DOD. It is beyond the abilities of humans to read and assimilate such large data sets and create comprehensive analytic products that leverage them. Said another way, as the amount of data grows, extracting actionable information, and fusing these results with relevant contextual or situational information to inform effective and timely action becomes progressively more challenging.

Some commercial technologies, such as cloud computing, are maturing and are widely available, but the development and use of data analytics to support DOD missions and business areas requires further research and development to exploit these advancements. Additionally, the unique challenges of the military tactical environment as well as the time and manpower constraints of tactical missions complicates adaptation of this technology as well as the development of data analytics to support mission requirements. On a much broader level, the foundations of D2D research can be used across many mission and business areas within the DOD to use data more effectively to save time and manpower costs.

(d) Human Systems

Human Systems research is focused on maximizing warfighter performance through focused and strategic research investments. The Department's primary focus has been to foster true synchronization between the hardware, software, and human elements of warfighter systems. This synchronization will enable effective and efficient mission performance, training, and warfighter selection, as well as affordable and effective equipment to support and conduct military operations. In fiscal year 2014, the Department plans to invest approximately $270 million in human systems.

The Department's Human Systems research is focused on three research areas: Personnel and Training, Human System Interfaces, and Biology-based Innovation. The research area of Personnel and Training focuses on improving warfighter training so that they are not using yesterday's technology, methods, and strategies. The training must address evolving mission complexities and dynamics. The Department has made substantial progress in developing tailored training approaches, mission essential competency development, fleet synthetic training, intelligent adaptive training and enhanced cognitive competencies.

The research area of Human Systems Interfaces is addressing the problem that most of the Department's current operating systems are rigidly data-centric vice flexibly information-centric. Research in this area is addressing these challenges with the realization that data quantity will continue to increase nonlinearly. Substantial progress has been made in human interaction with autonomous system and command and control decisionmaking.

In summary, the human sciences provide guidance on how to modify techniques, tactics, and procedures to achieve desired goals without an expensive materiel solution. Human systems research can provide tools for decisionmakers to evaluate

whether non-materiel solutions or modified materiel-solutions can meet desired requirements at lower cost.

(e) Medical Research and Capability Development

A somewhat specialized area of investment in S&T is defense medical research. The Department's research efforts in the biomedical arena reflect the focus on taking care of our people throughout the full spectrum of operations to include prevention of injury and disease both in garrison and on the battlefield, diagnosis and treatment at the point of injury, delivery of world-class medical care both en route to, and within medical treatment facilities and rehabilitation. Over the past decade, we have made remarkable progress in research areas aimed at minimizing bleeding and preventing hemorrhagic shock. The major investments in medical research; however, focus on acquiring a better understanding of the underlying cellular mechanisms and functional impacts associated with traumatic brain injury (TBI), particularly those characterized as mild TBI or concussion. For the battlefield commander, it is important to quickly assess the extent of this injury after a blast or blunt head trauma, in order to get prompt and appropriate medical care for the warfighter. To this end, the Department's investment has led to the development of a high definition fiber tracking method for use with existing magnetic resonance imaging (MRI) scanners to assess brain tracts for damage with much greater sensitivity than ever before. Complementing this new imaging capability is the development of a blood test for TBI to determine if brain cells are physically damaged after a traumatic event. This test is now in pivotal clinical trials for approval by the FDA and if successful, this test is expected to be the first objective diagnostic test for the presence and extent of TBI that may become part of the gold standard by which this condition is diagnosed. With regard to brain functional assessment, the Department's research efforts have led to a novel method for assessment of brain injury that is based on eye tracking metrics. This technology will also benefit the operational community by enabling assessment of performance degradation due to stress and fatigue.

Finally, and quite amazingly, we are now deploying servicemembers back into theater with ruggedized prosthetic legs that can withstand the rigors of the combat environment while dramatically improving agility. These new legs allow the user to move rapidly across uneven terrain with improved efficiency. The Department is capitalizing on advances in understanding neuromuscular control to allow users to more naturally control prosthetic devices by harnessing nerve signals from the brain and linking them to the device. Although most of the investment in prosthetics has focused on the lower extremities, significant progress has been made in the development of a prosthetic arm that mimics the natural function of the human arm. Future investment will focus on reducing the weight and increasing the degrees of freedom in the motions that can be achieved by these prosthetic arms. Many of the Department's advances in rehabilitation are improving the quality of life of amputees in the civilian population as well.

Important to the development of injury prevention measures, is the knowledge and understanding of the mechanisms and forces involved in creating the injury. To this end, our S&T research program has developed a small, lightweight, multiple axis accelerometer/pressure blast injury gauge that is worn by the warfighter and is capable of storing the pressure and force profile of their exposure. This information, combined with associated medical symptoms, will aid in modifications of future designs of the warfighter's protective gear. These gauges are currently deployed.

(f) Technology Watch/Horizon Scanning

In the fiscal year 2014 budget, we have a new low-cost, but high-risk effort to apply advanced data analytics to try to isolate and identify emerging "hot" science and technology areas. This type of approach is fairly well defined in industry for short-term financial prediction. We believe, but no one has proven, that the same non-parametric methods will apply to technology watch/horizon scanning. We will ask for industry bids to offer their software and modified for our purposes, then host the application at DTIC, for all DOD users to be able to access.

This is a high-risk initiative to bring emerging data analytics to bear on identifying significant changes in the global technology landscape. This effort will leverage a range of algorithms and data streams to provide both leadership and program managers more insight into evolving technical capabilities worldwide.

S&T INFRASTRUCTURE AND HUMAN CAPITAL

In order to execute programs that are designed to solve problems, an effective R&E enterprise must plan for and maximize its employment of people, facilities, and planning processes.

1. People

Within the R&E functional areas, we have to both shepherd today's workforce, as well as develop the future workforce. Over the past several years, we have seen some initiatives that have increased our flexibility for hiring people—this has helped.

While previous legislation has helped with recruiting new talent, we have also made gains in the acquisition workforce due in part to the hard work of the Acquisition Career Field functional managers, three of whom reside in ASD(R&E)—Science and Technology, Systems Engineering, and Test and Evaluation. The Department's responsible officials for each are the Director, Defense Laboratories; the Deputy assistant Secretary of Defense for Systems Engineering; and the Principal Deputy Assistant Secretary of Defense for Developmental Test and Evaluation. While we have made progress, I am concerned that the current budget and sequestration pressures will make retaining this workforce difficult.

(a) Science and Technology Workforce

As part of the strategic workforce planning initiative, the Department has completed two assessments of its Scientist and Engineer (S&E) workforce this year—the Science and Technology (S&T) Functional Community assessment and the Technical Workforce of the Science and Technology Reinvention Laboratories (STRLs) assessment. The S&T Functional Community assessment focused on the mission critical occupation of Computer Scientists indicated that there is increasing demand across the Department for highly-skilled and highly-trained individuals in emerging fields like cyber research, quantum computing, and artificial intelligence. The assessment also found that many of the skills necessary for the Department are best cultivated in-house because of the high degree of specialization needed and multidisciplinary requirements. The SMART program (Science, Mathematics, and Research for Transformation) was identified as a critical tool for successfully attracting, training, and preparing the future workforce. Using SMART, we have been able to compete for very high-quality talent.

The Technical Workforce of the STRLs assessment examined the more than 37,000 scientists and engineers working in the STRLs. The assessment emphasized the successes of greater flexibilities for STRL directors that legislative changes have produced, particularly Direct Hiring Authority (DHA). DHA, which is available on a limited basis only for individuals with advanced degrees, has reduced the average hiring timeline from nearly 100 days to just under 30 days. This flexibility was identified as critical to hiring the most talented scientists and engineers in an extremely competitive market. Attrition due to retirement has been identified as potentially impacting the ability of the STRLs to maintain the critical skills and competencies necessary to fulfill their mission. The assessment concluded that the ability of STRL directors to be flexible and adaptive in the management of their respective workforces is a key component to maintaining the scientific and technical excellence across the STRLs.

(b) Systems Engineering Workforce

The scope of the DOD engineering enterprise represents a remarkable investment of human capital. The Department, with its Services and Agencies, is one of the largest engineering enterprises in the world, with a nonconstruction engineering civilian workforce made up of nearly 76,000 engineers. The DASD(SE) serves as the Department's Functional Leader for the technical subset of the Defense Acquisition Workforce, which includes the Systems Planning, Research, Development and Engineering (SPRDE) (about 39,000 civilian and military) and Production, Quality and Manufacturing (about 9,000 civilian and military) career fields.

Today's DOD weapons, combat systems, and technical activities provide unprecedented capabilities to the Department and presents engineering challenges to the Department's engineering workforce. The Department has responded to these challenges, growing the SPRDE workforce 3.5 percent per year from 34,537 at the end of fiscal year 2008 to 39,807 at the end of fiscal year 2012. A strong government technical workforce balances the Department's partnership with industry by providing greater capability for the government to manage complexity and exercise technical judgment required to conceive, manage, invest in and oversee development of advanced weapon systems. In view of the programmed out-year weapons, combat systems and engineering initiatives, this workload, and the Department's need for world class engineering talent, is expected to continue well into the future. This environment will place greater pressure on the Department's ability to meet this continued demand for a multi-disciplined engineering workforce and adequately support increased program requirements.

The Department's engineering community has evolved over time to stay relevant to emerging defense challenges and, while systems engineering has always been an essential function, it becomes even more critical in a fiscally constrained environment. However, 12 percent of the SPRDE workforce is eligible to retire immediately. Many of the potential retirees will be those in senior and key lead SE positions on major defense acquisition programs. This highlights not only the potential loss of experienced SE workforce members, but also increases performance risks in programs and further highlights the need for the Department to continue support to maintain our engineering workforce as a national asset and critical function in support of the warfighter. DOD leadership is committed to further strengthening the systems engineering capability and capacity to assure there is a pipeline of qualified workforce members to serve current and future programs.

(c) Developmental Test and Evaluation Workforce

The DASD(DT&E) is the senior official responsible for the T&E Career Field in the acquisition workforce. DASD(DT&E) has also made significant progress in strengthening the T&E workforce, including revising the core education requirements to advance technical proficiency within the T&E profession, and the annual review to update the Defense Acquisition University T&E curriculum to enhance the T&E workforce's ability to meet tomorrow's challenges.

The current T&E acquisition workforce is 6,838 government and 1,765 military personnel for a total workforce of 8,603. The T&E workforce has increased from 7,420 in 2008 to our current level of 8,603. We continue to monitor impact of the budget pressures on the T&E workforce by providing assessments of the T&E workforce in future DT&E Annual Reports to Congress. The assessment will look at the ability to attract, develop, retain, and reward T&E experience to meet the needs of DOD.

(d) Science, Technology, Engineering, and Mathematics (STEM)

In addition to taking care of today's workforce, the ASD(R&E) has responsibility for the S&E workforce of tomorrow. The Department depends on over 100,000 S&E as well as other STEM professionals. In 2011, we established the STEM Executive Board which provides strategic leadership to the Department's STEM initiatives. The Board is comprised of Senior Executive Service-level representatives from the Services; USD Personnel and Readiness; Intelligence; and representatives of key acquisition components, and provides strategic coordination of DOD's STEM investments. Specifically, the STEM Strategic Plan and Implementation Plan align the Department's investments with DOD STEM workforce requirements and with administration STEM guidance, including robust, on-going impact assessments.

The future of the Department's STEM workforce depends on a robust education system that provides diverse pathways into STEM to meet the Department's mission. Numerous studies in recent years have called our attention to the need to improve STEM skills of U.S. students, who have fallen behind other nations. Through basic science workshops, increased funding for university research and other dedicated STEM programs, we are trying to stay connected to universities.

Within the ASD(R&E) portfolio, we have the National Defense Education Program (NDEP). This program supports the scholarship-for-service Science, Mathematics, and Research for Transformation (SMART) program, which provides financial support for undergraduate and graduate degrees in 19 STEM fields that are critical to the Department's future. Under SMART, we have attracted over 1,500 top quality researchers. To date over 700 students have completed their degrees and entered the DOD workforce. Of these, 82 percent remain employed in the DOD beyond their service commitment. We continue to make use of the SMART program to improve our workforce.

2. Facilities

As part of a much larger Office of Science and Technology Policy led effort to assess the overall status of infrastructure at our government labs dedicated to national security, the Department is currently conducting an assessment of Defense Laboratory facilities in order to more quantitatively and comprehensively evaluate the current state of DOD Laboratory facilities. The Department is also examining the process of how the Services currently prioritize military construction projects and how Laboratory projects are evaluated in this context. There are general concerns both within and outside the Department that Laboratory facilities are underfunded relative to the non-lab infrastructure in the Services. We are in the process of determining quantitatively if this is true. Without quantitative evidence, it is impossible to develop proper solutions that adequately address any problems.

Through this study, the Department will also be able to quantify the nature and scope of deficiencies at the Laboratories and the potential costs of rectifying them.

Anecdotal evidence suggests that Laboratories' sustainment, restoration, and modernization efforts lag those of the rest of the Department, but by how much and to what extent is unclear. The successful uses of the expansion of minor military construction authorities to Laboratories suggest that there are indeed gaps, and the Department is committed to eliminating them. With a more accurate understanding of any gaps and their size, the Department can take the necessary steps to ensure that our Laboratories' facilities remain state-of-the-art and capable of supporting today's mission and future requirements.

In addition to quality laboratories, the Department also needs high-quality test facilities. Planned T&E infrastructure upgrades have been partitioned between System Integration Laboratories (SIL), Installed System Test Facilities (ISTF), and Open Air Ranges (OAR) investment to provide a capability mix that effectively supports technology experimentation and design performance verification testing. This investment benefits S&T through providing more modern and representative test facilities. Planned upgrades are focused in three investment areas. First and foremost, the Department is improving its System Integration Laboratories at Eglin Air Force Base, FL and Naval Air Station Point Mugu, CA to allow programming of flight test mission data files and EW libraries to reflect foreign integrated air defense systems (IADS) threats. As mentioned earlier, the Department is upgrading our next-generation EW emulators to mimic modern IADS and finally, we are upgrading open-air ranges to better iterate live-virtual demonstration exercises.

We are also very interested in enhancing our cyber test facilities. The increasing demand for cyber test, training, and experimentation will challenge our capabilities and capacity of our cyber ranges. We have transitioned the National Cyber Range (NCR) from DARPA to the Test Resource Management Center (TRMC), where we will operationalize its capability to support test and training. The Department will continue investment in this critical infrastructure to increase both capacity and capability for cyber training, testing, and experimentation. Once operational and accredited for the required level of classification, the NCR will have increased capacity, with standard services, more efficient sustainment of capability, and fail-over capability to improve Cyber R&D.

3. Department R&E Planning Process

A key strength of DOD's S&T Enterprise is its substantial emphasis on coordinated research planning. The Department's S&T components devote great care and attention to ensuring that DOD's research investments are well planned and coordinated. In these challenging budgetary times, it is important to strengthen these efforts to ensure that we receive the utmost value from our investments in science and technology.

The overarching framework of the Department's S&T joint planning and coordination process is called Reliance 21. We are resurrecting and enhancing Reliance 21, a process with roots that go back several decades, which has undergone continual renewal and refreshment as circumstances evolved. The Reliance 21 framework is led by an S&T Executive Committee (ExCom) that embraces the major Departmental S&T organizations, including the Military Services and DARPA who sit at my side at this hearing today. The S&T ExCom, and the S&T Deputies Committee that serves as its primary operating arm, meet several times per month to coordinate both strategically and at a tactical level to harmonize resources and coherently address emerging challenges. Once every year, the 3-star and 2-star members of the S&T ExCom conduct an intensive multi-day planning exercise of the Department's out-year research investments, to ensure proper attention to potential gap areas, and to minimize unwarranted overlaps. This event is conducted in close coordination with the future requirements specialists of the Joint Staff.

Underpinning the S&T ExCom leadership is an ecosystem of technical groups known as Communities of Interest (CoI) and S&T Priority Steering Councils (PSCs). There are 18 of these groups that span almost all of the cross-cutting areas of science and technology in the Department. Examples of such areas include Advanced Electronics, Sensors & Processing, and Cybersecurity, among many others. These groups are populated by the Department's subject matter expert leaders drawn from the Services, Defense Agencies, and from OSD. The subject matter experts often have decades of experience in the Defense S&T research enterprise and are an asset in DOD's efforts to generate technology surprise and rapidly convert that surprise into operational capabilities. Fundamentally, the subject matter experts guide and coordinate the portfolios of research investments in each of the CoI and PSC areas. They do this primarily through development of research roadmaps and investment plans. The roadmaps are used extensively to guide long-term budget decisions and to influence near-term investment decisions in each of the components. The CoIs and PSCs also provide forums for developing younger staff and for

maintaining technical awareness of S&T developments both inside and outside DOD. Each year, roughly half of the PSCs and CoIs brief the health, direction, and connectedness of the programs in their portfolio.

In addition to this coordinated approach across the Department, we have taken steps to better leverage Industry's Independent Research & Development (IR&D) for which DOD reimburses industry approximately $4 billion annually. IR&D projects are a critical source of technology innovation for DOD. Under the Better Buying Power initiative, ASD(R&E) was charged to reinvigorate IR&D. The key challenge identified was communication—industry wanted information about Department investment priorities to help them better plan their IR&D projects, and DOD planning was hampered by limited insight into industry IR&D projects. The Defense Innovation Marketplace website (www.defenseinnovationmarketplace.mil) was developed to provide a one-stop-resource for Department priorities so industry could better align their R&D investments. Industry can also securely share IR&D projects with the government, allowing S&T and acquisition program managers to leverage this data to inform future program planning.

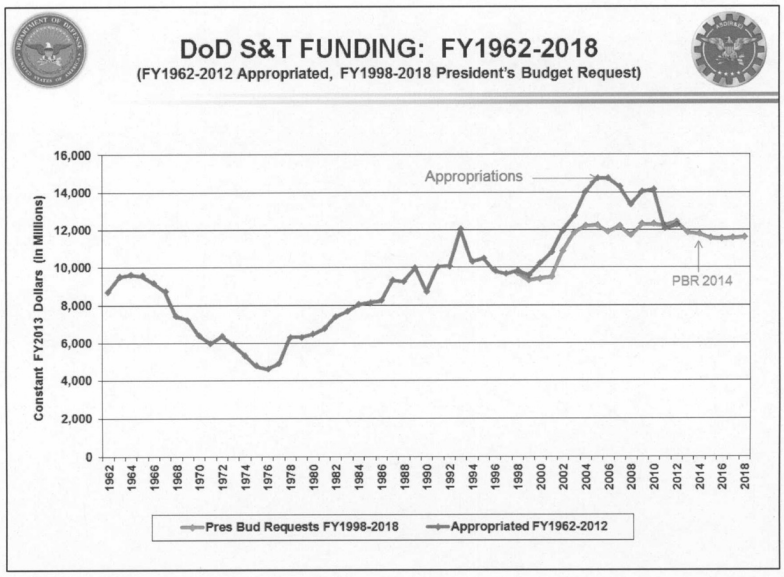
BUDGET PRIORITIES

1. DOD S&T Trends

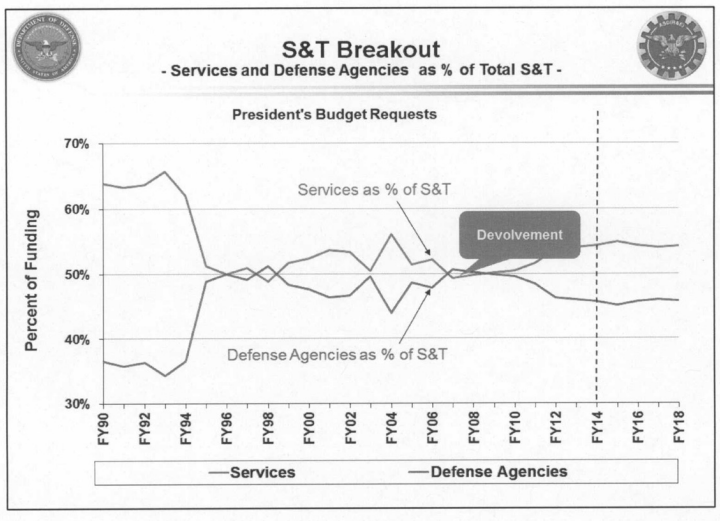
The fiscal year 2014 President's budget request (PBR) for S&T is $11.98 billion, which represents a nominal growth from the fiscal year 2013 PBR of $11.86. For R&E, the fiscal year 2014 PBR is $24.04 billion, which is a 2.6 percent decline from the fiscal year 2013 PBR of $24.27 billion. This is because the budget category of Advanced Component Development and Prototypes declined 4.47 percent, in real buying power. See table:

($B)	PBR 2013	PBR2014 (FY13 CY $)	% Real Change from 2013 PBR
Basic Research (6.1)	2.117	2.164 (2.128)	.53%
Applied Research (6.2)	4.478	4.627 (4.549)	1.59%
Advanced Technology Development (6.3)	5.266	5.192 (5.105)	-3.06%
DoD S&T	**11.861**	**11.984 (11.782)**	**-.67%**
Advanced Component Development and Prototypes (6.4)	12.409	12.057 (11.854)	-4.47%
DoD R&E	**24.270**	**24.040 (23.636)**	**-2.61%**
DoD Topline Budget	**525.449**	**526.637 (518.854)**	**-1.26%**

We must continue to balance the investment with all our partners across Acquisition, Technology and Logistics. We also recognize R&E provides lower cost options which become more important during budget austerity. The fiscal year 2014 President's budget represents a strategic choice made by the Department to preserve, to the greatest extent possible, technology-based options for the future. While we expect continued pressure on the S&T and R&E budgets over the next several years, it is significant to note that there is recognition of the value of preserving future options—a characteristic of R&E. Taking a longer term view, the chart below shows the actual S&T investment in constant year 2013 dollars, since 1962. The budget request for S&T has been largely flat since about 2003. This highlights another key characteristic of a healthy S&T program: long-term stability. It is important to not have big fluctuations in R&E funding from year to year so as to maintain a stable workforce.

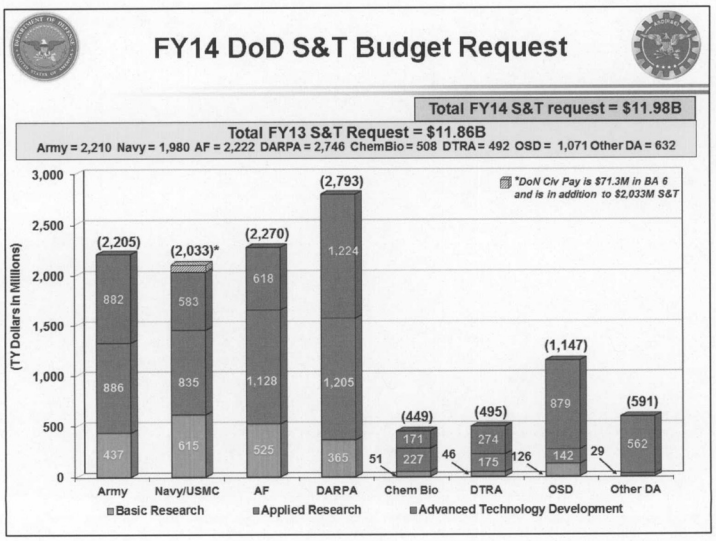


Another macro trend we see in the DOD S&T budget is highlighted in the next chart. Since the fiscal year 2008 President's budget request, we have made a conscious choice to focus more of the investment to the Services, in relation to Defense agencies and the Office of the Secretary of Defense. We still have an investment of $5.48 billion in the Defense agencies and the Office of the Secretary of Defense for S&T in fiscal year 2014, but this is down from a figure of $6.09 billion as recently as fiscal year 2010. Much of these funds were with programs that devolved to the Services.



Finally, the chart below displays the S&T investment by major components. Investment in S&T for the three Services is between $2.0 and $2.2 billion and DARPA

remains the single largest investment with $2.8 billion in fiscal year 2014. The other components make up a much smaller piece of the S&T portfolio.



The fiscal year 2014 S&T budget also supports White House priorities in the areas of advanced manufacturing, robotics and autonomous systems, cyber security, hypersonics, and electronic warfare described in earlier sections.

2. ASD(R&E) Portfolio

Shifting focus from the overall DOD S&T to the ASD (R&E) investment portfolio, the fiscal year 2014 S&T budget of $738 million is 5.5 percent higher than fiscal year 2013 budget of $700 million. The fiscal year 2014 budget reflects a significant change in major investments that align to the defense strategy, DOD S&T priorities and OMB priorities described above. These fiscal year 2014 S&T investment changes include:

- Termination of five existing programs/program elements to create a new $45 million 6.2 Applied Research for the Advancement of S&T Priorities Program to focus on the seven S&T priorities, applied research projects, concept explorations, and technology solutions for future military needs. In fiscal year 2014, this new program will support the aforementioned autonomy pilot and acceleration of engineered resilient systems. The remaining funds will be competitively allocated to the other PSCs generated proposals. All funding in this program will be executed by the components.
- Transfer of responsibility and $16 million in funding for the Historically Black Colleges/Minority Institutes program from Army to OSD consistent with the National Defense Authorization Act for Fiscal Year 2012 including realignment of additional $15 million for Centers of Excellence.
- Realignment of $13.8 million in the Emerging Capabilities Technology Demonstration program to address developmental prototyping.
- Realignment of $60 million from three existing programs for the standup of a new Strategic Capabilities Office (SCO) responsible for analyses of emerging threats with emphasis on innovative and architecture-level concepts, intelligence concepts, red teaming, and conducting disruptive technology demonstrations.
- Realignment of $130 million for the Advanced Innovative Technologies Program to accelerate a land-based prototype of an electromagnetic railgun for improved theater missile defense capability. This program is not S&T, but ACD&P.

LEGISLATIVE PROPOSALS

Prize Authority

The Defense Budget Priorities and Choices guidance, issued in January 2012, calls for "cutting-edge capabilities that exploit our technological, joint, and networked advantage." Extending the authority for Prizes for Advanced Technology Achievements, requested by this proposal, will allow the Department to continue the cutting-edge technology prototyping that results from the prize challenges. Partnerships created under this legislation also strengthen the ties of the Department with industry and universities. Prize competitions are unlikely to replace the traditional acquisition process in the DOD, but for specific technology problems, it is a method that has demonstrated to be tremendously useful for stimulating and incentivizing a broad spectrum of individuals to offer solutions to problems of significant interest to our Nation's warfighters.

SMART

The Science, Mathematics, and Research for Transformation (SMART) is a Scholarship-for-Service program designed to produce the next generation of DOD S&T Leaders as our current workforce is aging and eligible to retire. The program accomplishes this goal by providing support to undergraduate and graduate students for their educational expenses in exchange for service in our DOD facilities. This program matches the SMART scholars with DOD laboratories and other Defense agencies where mentors transfer their STEM knowledge to the students and introduce them to the DOD culture beginning with internships and culminating in full-time employment at those facilities. The Department is asking for a revision of the SMART legislation that would create three major benefits; (1) increased flexibility to administer the program, (2) reduced stipends to make them more consistent with other Federal scholarship-for service programs, and (3) removal of the restriction that only U.S. citizens can participate in the program.

Software Licensing

The DOD develops significant quantities of computer software in a variety of areas such as modeling and simulation, training, and command and control. A legislative proposal has been prepared to allow the DOD to protect its software and to facilitate the license process for transfer to commercial firms. In the course of that licensing action, it would be protected from release to the general public in response to a Freedom of Information Act request for up to 5 years providing the commercial licensing partner adequate time to develop the product, prepare user documentation, and deploy to both military and commercial markets. At the same time the commercial firm's investment of funds to underwrite these product activities is protected from undue competition. The request is for a 5 year limit on this pilot program. This provides adequate time for DOD to develop data that would justify a future request for extension, modification, or cancellation of this authority.

SUMMARY

I would be remiss if I did not mention the impact of sequestration. At the macro level, the reduction to S&T investment is roughly $1 billion in fiscal year 2013. Since in many cases, the work in S&T is sequential, the work planned for fiscal year 2013 will be deferred to fiscal year 2014—and reduces the work planned in fiscal year 2014 by that same $1 billion. Some of this reduction will be seen at our government labs, but other impacts will be seen in government and universities. For example, we expect the total investment in universities to decline by about $250 million.

In closing, I am proud to say our R&E enterprise is delivering capability and value for the Department and Nation. I would also like to thank Congress for your continued support of the S&T program of the Department of Defense. As we enter a new strategic era, it is important to examine all Department investments. It is just as important to understand the value of investments like R&E that strengthen the overall capabilities of the Department. With your support of the fiscal year 2014 President's budget request for RDT&E, you will allow our community to continue to deliver future capabilities for the Department.

Senator HAGAN. Thank you.

Dr. Prabhakar.

STATEMENT OF DR. ARATI PRABHAKAR, DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Dr. PRABHAKAR. Thank you, Madam Chairman and Senator Fischer. It is really a pleasure to be here with you today.

DARPA's objective is a new generation of technology for national security, and to realize this new set of military capabilities and systems is going to take a lot of organizations and people. But DARPA's role in that is to make the pivotal early investments that change what is possible, that really lets us take big steps forward in our capabilities for the future.

So today, that means that we are investing in a host of areas. We are building a future where our warfighters can have cyber as a tactical tool that is fully integrated into the kinetic fight. We are building a new generation of electronic warfare that leapfrogs what others around the world are able to do with widely, globally-available semiconductor technology. It means we are investing in new technologies for position navigation and timing so that our people on our platforms are not critically reliant, as they are today, on the Global Positioning System. We are investing in a new generation of space and robotics, advanced weapons systems, new platforms. Beneath all of that, we are building a new foundational infrastructure of emerging technologies in different areas of software and electronics and material science, but also today new technologies that are emerging from the biological sciences.

Now, with all of that together, if we are all successful, our aim is to create for our future commanders and leaders real options, powerful options, for whatever threats our Nation faces in the years ahead. That work is the driver behind all of our programs. It is the reason that the people at DARPA run to work every morning with their hair on fire because they know that they are part of a mission that really does matter for our future security as a country.

I really want to thank this subcommittee for the work that you have done to support us in many ways, including flexible hiring authorities as well as budget support. That has been essential in our ability to do our work.

I look forward to taking your questions, along with my colleagues.

[The prepared statement of Dr. Prabhakar follows:]

PREPARED STATEMENT BY DR. ARATI PRABHAKAR

Chairman Hagan, Ranking Member Fischer, members of the subcommittee, thank you for the opportunity to testify before you today. I am Arati Prabhakar, Director of the Defense Advanced Research Projects Agency (DARPA).

Three major factors drew me back to DARPA last summer after 19 years in other roles. The first was DARPA's disproportionately large impact on our current national security and technology capabilities. The second was the challenge of driving the technologies that will be cornerstones of our national security in the complex world we face in the years ahead. The third was the privilege of leading this unique agency, filled with people who come to work each day in vigorous pursuit of our important mission.

Today I'd like to tell you about each of these aspects of DARPA. I will include a discussion of our objectives and strategies, specific areas of investment, and our budget in the President's fiscal year 2014 request.

The starting point for our discussion today is the future security of the United States. We all understand the world is complex and changing in ways that will pose new threats to our national security. We all understand that resources will be con-

strained as we reshape defense budgets. But U.S. security capabilities must remain second to none despite these uncertainties and pressures. New technology has consistently created better options for our leadership—and better security outcomes for our Nation. Today, it is vitally important to continue to focus on the technology investments that will lead to a new generation of national security capabilities for our future. This commitment is reflected in the President's budget request for DARPA in fiscal year 2014.

Before turning to DARPA itself, I'd like to set the context for our Agency in our Nation's research and development (R&D) efforts. DARPA is a projects agency, and we accomplish our objectives through deep engagement with companies, universities, Department of Defense (DOD) and other labs. Our success hinges on having a healthy U.S. R&D ecosystem. Within DOD Science and Technology (S&T) efforts, our role is to invest in high-payoff opportunities that often require taking significant risk. We work closely with our colleagues in the Service S&T organizations, sometimes building on their early research and drawing on their technical expertise, and often relying on them to help us transition successful results to military use.

DARPA'S IMPACT

DARPA's recent transitions won recognition last fall when then-Secretary of Defense Leon Panetta gave the Agency the Joint Meritorious Unit Award, recognizing numerous contributions for the war effort. The award singles out the "creative intellect and keen expertise" that delivered "innovative cutting-edge technology to save lives and improve mission success amidst constantly evolving threats." Responding to urgent needs from troops on the ground, DARPA created and fielded a wide range of highly effective tools. These included a system that delivered three-dimensional views of the battlespace to operational and intelligence users, a radar pod to track threat vehicles and dismounted personnel, a radio system capable of interoperable communications and large data transmissions, a detection system that assesses blast exposure and medical risk to personnel, and a framework for the analysis of large amounts of data that provided unique and valuable insights to help answer key strategic and operational questions.

DARPA program managers, staff, and our partners were all excited to receive this recognition for what we work towards every day: creating new technological solutions and transitioning them into practice.

Because DARPA's enduring mission is to change the game in our favor when it comes to U.S. security capabilities in a rapidly shifting global context—and to do that by creating surprise for our adversaries and preventing surprises to our own forces—our warfighters long have depended upon many military systems that originated in earlier DARPA work. Aircraft with stealth capabilities, unmanned aerial vehicles (UAVs), night vision for our warfighters who now essentially "own the night" largely because of infrared imaging, the seemingly omnipresent global positioning satellite (GPS) capabilities for navigation and precision guided weapons, an arsenal of advanced communications and computing capabilities, and advanced intelligence, surveillance, and reconnaissance (ISR) are all well known and publicized examples. The list goes on and on, and it includes revolutionary changes in how the world thinks about important areas of science and technology, including information technology and materials science. The list also includes some elegant and important advances that do not get public attention by the nature of their applications. Simply put, our military has taken DARPA-initiated advances and used them to change warfighting dramatically. This is how we keep the scales tipped in our direction.

LOOKING TO THE FUTURE: TECHNOLOGIES FOR THE NEXT GENERATION OF NATIONAL SECURITY

Today, as the Nation moves to the end of the active engagements of the last many years, it is time to look ahead and ask the fundamental questions for DARPA's mission. How do we create highly effective options for our future leaders in the face of the national security challenges of the coming decades? How do we dramatically change warfighting, once again changing the game in our favor faster than others can respond? How will we deter and defeat the many kinds of threats that many kinds of actors around the globe will attempt?

DARPA's new framework, captured in a document transmitted to this committee recently along with the President's fiscal year 2014 budget request, describes how we think about this all-important question. "Driving Technological Surprise: DARPA's Mission in a Changing World" places great importance on the rapidly changing context in which our military leaders, warfighters, and DARPA now are operating. It explains how we anticipate, explore, and achieve the concepts and tech-

nology on which the Nation's future deterrent and defense capabilities depend. I will draw in part on that framework in my testimony.

The United States has seen great change that has affected our civilian and defense capabilities, positioning, and plans that challenges us every day. There is nothing new about needing to deal with changes in our adversary's capabilities. That is a big part of the history of armed conflict and its prevention or successful execution.

Today's Environment and DARPA's Strategic Objectives

But today's environment is different from the past. First, the Nation faces complex security challenges. Some are very real and some are potential in nature—but all demand viable options for our Nation's leadership. We are finishing a counter-insurgency operation and building local security capabilities in Afghanistan. An array of diplomatic, intelligence, and possible military measures must be ready if needed to address nuclear uncertainties posed by Iran and North Korea. Our government and private networks deal with the growing onslaught of more capable and frequent cyber-attacks from many sources on an ongoing basis. Potential adversaries are deploying sophisticated capabilities to contest our ability to project military power. A look into the future only adds uncertainty. The proliferation of nuclear, chemical, and biological weapons of mass destruction or terror; the flare-up of tensions among nations in hot spots around the world; growing pressures in the urbanizing developing world; and the globalization of technology and new R&D are all trends we can see.

This shifting, unpredictable national security environment demands a wide range of capabilities for the future and the agility to both anticipate and respond to whatever comes.

I want to underscore a point: the technology base upon which our military systems are critically reliant is highly globalized. This introduces potential vulnerability in both the assurance of supplies and the security of the supply chain. At the same time, other players have the same access to this supply of highly capable components, and many have used them to quickly develop weapons systems with highly advanced capabilities. This pattern of globalization, wide availability, and growing vulnerability pervades most of the core technologies upon which our defense systems rely. Our challenge is to create an edge for U.S. national security purposes in this environment.

The second significant factor driving our objectives going forward is the possibility of a change in public investment for national security. Because DARPA's prime directive is to prevent strategic surprise and enable our superiority, we must consider what will be required to meet the Nation's security needs even in these circumstances.

The uncertainties we face—threat uncertainties and fiscal uncertainties—do not change the fact that the Nation relies on DOD to deter war and protect the security of our country, and DARPA's role here is vital.

DARPA's Approach

Our first two primary objectives are:

(1) Demonstrate breakthrough capabilities for national security, and
(2) Catalyze a differentiated and highly capable U.S. technology base—critical to achieving the first objective.

Several approaches shape our thinking as we attack the need for breakthrough capabilities for national security:

(1) Game-changing new systems technologies. Today's warfighters rely on systems from aircraft to navigation to communications that trace their history to earlier DARPA work. Looking ahead, some of these may become vulnerabilities as sophisticated adversaries also understand how crucial these systems are to warfighting. So, DARPA seeks to create the next generation of new capabilities that once again changes the game in our favor faster than others can respond.
(2) Layered, multi-technology warfighting concepts. Modern warfighting is too complex for a single new capability to deliver sustained superiority across a variety of scenarios. But combining multiple technology advances by layering and integrating them can lead to a revolution in capabilities. Looking ahead, we can imagine coordinated local position, navigation, and timing (PNT); adaptive electronic warfare; manned and unmanned systems working in harmony; tactical cyber effects; and advanced ISR—all woven together in ways that create decisive surprise in tomorrow's conflicts.
(3) Adaptable systems and solutions. While military technology and weapon systems have continued to evolve and mature over time, our military engage-

ments of the last 20 years have been fought with systems developed largely for Cold War scenarios. Our warfighters have had to adapt for the realities on the ground. Today when we consider future engagements, we can more readily imagine a host of diverse environments and adversaries. In an uncertain world, adaptability is critical. We won't always know what we will need for tomorrow's battle, and our adversaries will change their tactics and technologies over time. So systems that can be readily upgraded and adapted in real time to changing surroundings and conditions will play an important role.

(4) Innovation to invert the cost equation. Today we seek to use innovation to radically invert the cost dynamic. How can we impose more cost on our adversaries and less on ourselves, thereby increasing our deterrent? Can innovative systems architectures, autonomy, adaptability, and new processes offer new possibilities? These approaches may allow us to reinvent development, production, logistics, operations, and maintenance in ways that radically change the cost equation.

Two themes shape our efforts to catalyze a differentiated and highly capable U.S. technology base:

(1) Exploiting and transcending commercially available technologies. We seek to be the best user of globally available technologies—to use them with greater creativity to solve problems more quickly, efficiently, and flexibly. This means novel systems architectures as well as integrating specialized niche technologies with commercially available components to create unique solutions.

(2) Catalyzing new national technology capabilities. Entirely new technologies open the door to national security applications that can't even be imagined beforehand. We recognize that many of these technologies will also globalize. But the time advantage to the United States, if we pursue them first, can be substantial and make all the difference. We approach this challenge in several ways:

- Exploring new technology possibilities from fertile basic and interdisciplinary research. Universities, government labs, and private R&D organizations are bubbling with intriguing new research across many disciplines and new interdisciplinary fields. Some hold the seeds for the next technology revolution. We actively search for these promising activities and explore where these new insights might lead.
- Building foundational technology infrastructure and communities. DARPA has a long history of building technology infrastructure that becomes the foundation for wide arrays of applications. Today, we are using the same approach in new fields. Our programs create the tools, techniques, and communities that scale well beyond the period of our investment.
- Demonstrating the new capabilities that technology enables. Changing minds about what's possible rarely happens just through writing papers and reports. Projects that build prototypes show how technical breakthroughs enable new capabilities.

The President's Fiscal Year 2014 Budget

The President's fiscal year 2014 budget proposal for DARPA is $2.865 billion. This is on par with the $2.817 billion originally budgeted for DARPA in fiscal year 2013, but has now been reduced to $2.785 billion following congressional action. The fiscal year 2013 budget has been further reduced by approximately $223 million as a consequence of sequestration.

Before discussing our fiscal year 2014 plan, let me explain our fiscal year 2013 status under sequestration. As I'm sure you know, sequestration is having a significant effect on our work during this fiscal year. At DARPA, we have prioritized within each Program Element to execute cuts as intelligently as possible, but with cuts of this size there are real consequences. We are projecting up to 14 days of furloughs for our civilian government employees, and we are delaying or eliminating programs as a result of the 8 percent cut in each Program Element. While the planned furlough days are of course a financial concern for our employees, our people are also deeply frustrated they will not be allowed to do their jobs on these days. This unfortunate message makes it that much harder to recruit and retain the stellar individuals we need to accomplish our mission. Programs across the Agency are affected by the sequestration cuts. Two examples include Plan X and the Microtechnology for Positioning, Navigation and Timing (microPNT) program. Plan X, which aims to integrate cyberwarfare and kinetic fighting, is being cut by 43 percent in fiscal year 2013, delaying its start by 5 months. The microPNT program, which is developing the capability for precise, self-contained PNT in severe environments, will see a 9

percent cut, delaying testing with the Air Force and driving additional schedule extensions.

Looking forward, the proposed fiscal year 2014 budget would provide us with resources to address or—in some cases, begin to address—our essential programs. I'd like to highlight a number of areas that range from particular military systems to broader, enabling technologies.

Cyber foundations for a scalable new trajectory: DARPA's cyber programs tackle two aspects of this broad challenge that are redefining the rules of warfighting. One is to create the capabilities that will allow us to move beyond today's "detect and patch" approach to a more fundamental defense of our cyber systems. We aim to provide cybersecurity and survivability solutions that enable DOD information systems to operate correctly and continuously even when attacked. The second aspect focuses on cyber effects in tactical warfighting scenarios. We can readily imagine a future in which cyber warfare is fully integrated with kinetic warfare. DARPA's cyber offense efforts aim to create the tools that bridge these domains, for example, by providing simulations of cyber effects, battle-damage assessments, and layers of authority and control.

Cost-effective space systems in a newly contested environment: Unsustainable cost growth has materially affected the development of future U.S. capabilities in the all-important environment of space upon which DOD, the intelligence community, and commercial sectors rely. DARPA is tackling these challenges by focusing on affordable routine access, agile systems development at lower cost, survivable and resilient systems, disaggregated and simplified systems, and a holistic approach to space situational awareness. For example, one DARPA effort is striving to drive the cost of space access down to $1 million per launch and increase the tempo to single-day turnarounds. Creatively—and ambitiously—another program is exploring cooperatively harvesting and reusing valuable retired satellite components to build an entire new space system in geosynchronous orbit. If successful, this would be a major contribution to achieving the goal of reducing today's overall satellite system cost by 90 percent.

Air Dominance: Our forces have had the upper hand in air combat for many years now. But as others use globally available technologies to build new and sophisticated systems, resting on our laurels would be a dangerous course. With the support and endorsement of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Frank Kendall, DARPA has teamed with the Air Force and Navy to study the challenges of air dominance for the next generation. The working group is investigating how we can build on our current capabilities with new technologies and concepts, inverting the cost equation to force future adversaries to spend much more to counter than we do to field and employ. The team is taking a broad, integrated approach, looking at electronic warfare and sensing across the electromagnetic spectrum, communications and networking, space, cyber, weapons, and platforms. We anticipate this study effort will lead to new initiatives, with the ultimate goal of ensuring the United States continues its air superiority in the 2020–2050 timeframe.

Countering Weapons of Mass Destruction (WMD): We are pursuing efforts to increase efficacy and accelerate the timeline for bioweapon threat response, including novel techniques that will enable the human body to directly manufacture its own vaccines, bypassing traditional vaccine manufacturing processes that can take months. In addition, we are studying current challenges in countering chemical and nuclear WMD threats. For example, we are investigating a defense-in-depth approach, combining novel detection methods and big data intelligence analytics to achieve a more robust, layered solution. We are also looking into new medical countermeasures for increasing the survivability of victims of acute radiation poisoning.

Position, navigation, and timing (PNT) capabilities beyond our critical reliance on GPS: DARPA's recent programs in PNT originally sought to take GPS-like capability to the places where GPS currently does not operate, such as indoors, underwater or underground. As concerns surfaced about our critical dependence on GPS, those initial investments are starting to create GPS alternatives, as well as new enablers for future military systems. We have developed micro-PNT technologies and are transitioning them to use. We are developing new inertial measurement units and clocks that use atom interferometry for very long duration missions, as well as techniques that use available signals—from television, radio, cell towers, or even lightning—to augment or replace the location information that GPS currently provides. In keeping with the drive for adaptability, our new approach to full navigation systems integration could provide rapidly configurable solutions for the many types of platforms that require advanced PNT.

Electronic warfare (EW) to counter and move beyond adversaries' advancing capabilities: We face important challenges as we seek to protect our assets and deploy EW capabilities. Not the least of these is the reality that 90 percent of the elec-

tronics needed in an EW system can now be bought commercially. DARPA is attacking these challenges. For instance, DARPA is developing a new architecture for the radar antenna arrays with which ships and planes transmit and receive radar pulses. The goal is to make them in modular fashion, obviating the need for unique designs for each new application and permitting new and multiple modes of use. This has the potential to drive future radar costs down significantly, while simultaneously improving performance. Another challenge, and there are many, is that the system performance of many radios and radar units is constrained by the performance limits of electronic components inside those units. DARPA aims to drive technology capabilities well beyond commercial specifications and to extend important electronic components to performance regimes unreachable by commercial technology.

Engineering biology tools to engineer microorganisms for materials with new properties: Engineering biology is emerging as a new field as researchers across multi-disciplinary labs have started to design and construct genetic pathways, networks, and systems to harness the powerful synthetic and functional capabilities of biology. We can see the potential to develop new and transformative materials, sensing capabilities, and therapeutics. But synthetic biology today is still a multi-year, ad hoc, trial-and-error process constrained to a limited number of simple products. DARPA's investments in the Living Foundries program are developing the tools and technologies to create a new engineering practice, speeding the biological design-build-test cycle and the rate at which we realize novel products and capabilities. Drawing upon and building on the research base, these efforts will begin to create the foundational infrastructure for engineering biology. Some of the first outputs may include new materials and medicines such as antifungals, lubricants, and energetic materials. Beyond these are a new generation of products with properties we can only imagine today.

Big data capabilities to draw insight from multiple data sources: Exponential improvements in computing power, network bandwidth and storage density combined with ever more pervasive sensing and measurement technologies give us enhanced tools for drawing information and insights from massive, heterogeneous data sets. In the national security realm, harnessing big data offers special challenges. National security often involves actors with a vested interest in remaining unobserved. Data sets may be corrupted, incomplete, or disaggregated to the point that sophisticated technologies are required for cleanup. Data sets may be multimodal, real time-streamed, or on a scale for which storage isn't feasible and requires new processing approaches. Moreover, in many national security applications, inferences must be drawn, relationships deduced, or anomalies detected working solely from data sets that are weak proxies for the underlying quantities of interest. The varied ways in which data are gathered pose challenges in fusion. While the cost of investigating false alarms is often high, the consequences of a missed detection are even greater. These challenges are being addressed across DARPA's big data portfolio. The effort begins at the basic science level and also addresses fundamental computational issues such as novel algorithm design, natural language processing, and architectures for efficient processing of streamed data. At the other end, DARPA is working closely with national security agencies on operational data to ensure continuous transition of tools as programs progress.

Brain function research: DARPA plans to build on its past and ongoing research to help advance a new understanding of brain function to treat injury, create new brain-machine interfaces, and inspire new algorithms and hardware. Earlier this month the President announced an initiative to revolutionize our understanding of the human brain. DARPA's brain function research will play an important role in the initiative, with the goal of understanding the dynamic functions of the brain and demonstrating breakthrough applications based on these insights. DARPA aims to develop a new set of tools to capture and process dynamic neural and synaptic activities, and explore ways to dramatically improve the way we diagnose and treat warfighters who are suffering from post-traumatic stress, brain injury and memory loss.

I want to note that we pursue technologies like these because of their promise, but we understand that in this pursuit, we might be working in areas that raise ethical, legal, security, or policy questions. Here, our job is twofold. We must be fearless about exploring new technologies and their capabilities; this is our core function and our Nation is best served if we push these frontiers ahead of other countries. At the same time, we must raise the broader societal questions and engage those who can address them. We ensure our work adheres to laws and regulations. In new and uncharted territory, we reach out to a variety of experts and stakeholders with different points of view. In many instances, technology solutions can be part of the answer to new concerns. But we recognize that at their heart,

these are societal questions that require a broader community be engaged as we explore the technological frontier.

A wide array of other DARPA programs also reflects our investment approaches for breakthrough systems and technologies. They include programs in maritime and undersea systems, hypersonics, communications, ISR, robotic systems, innovative manufacturing technologies, adaptable sensor systems, and unconventional computing platforms. More broadly, we also invest in early-stage research efforts across physics, materials science, mathematics, and interdisciplinary fields with the potential for future technological applications. The President's fiscal year 2014 budget includes funding for this critical work.

KEEPING DARPA ROBUST AND VIBRANT

To accomplish our vital mission, it is essential that we keep DARPA robust and vibrant. So our third objective is to ensure a highly functional environment and the foundation for a strong culture.

With just 210 government employees we carry out 250 programs across 5 technology offices. How is this possible? In addition to having a cadre of very capable support functions and contractors, we rely heavily on active engagement with the technical community and users, as I emphasized earlier. Our success hinges on our ability to work with tiny companies to universities and major contractors to labs of every stripe. It hinges on our relationships with and the work of the users of our results across DOD.

DARPA's program managers are the core of our organization, and they are stellar. Each is a leader who brings to DARPA an adventurous spirit and a deep conviction that his or her technology vision will change the world. They come to DARPA because this is the place that gives them the opportunity to take breakthrough technologies to fruition. Our program managers generally serve 3- to 5-year terms, leading to a constant flow of new people and fresh views.

That is why our hiring authorities are so important to us. DARPA uses a dynamic mix of hiring and retention authorities enabling the Agency to continue to hire and retain the Nation's most qualified technical experts from industry, academia, and the private sector with speed and flexibility not allowed by standard civil services processes. Moving forward, maintaining and fostering a robust and vibrant DARPA hinges on our continued ability to recruit and retain the people who will meet the challenges of an ever-changing threat environment.

I would like to thank the subcommittee for its continued support of DARPA's hiring authorities. It has been enormously helpful to us, and we simply could not attain our high caliber staff without it.

FROM BASIC SCIENCE TO MILITARY ADVANTAGE: HOW A CLOCK COULD MAKE A DIFFERENCE

Let me conclude with a specific example of how we do our work—one of the numerous individual efforts underway in our portfolio today.

Earlier in my testimony I cited our important work on position, navigation, and timing systems as we strive to develop capabilities beyond what GPS systems offer us today. Position and time is oxygen for our warfighters, but GPS signals can be degraded or denied by adversaries who aim to jam or spoof our signals.

One of our novel PNT approaches captures how DARPA's ability to think outside the box, and our constant search for new ideas and surprises, can lead to the hard-nosed practical solutions we must have for technological superiority in national security.

Frequency and timing devices are essential components in modern military systems. The stability and accuracy of these devices affect the performance of communication, navigation, surveillance, and missile guidance systems. Atomic clocks are at the core of many of these systems, either directly or by synchronization with a master clock.

DARPA is now building on exquisite Nobel Prize-winning science conducted in the mid-1980s that enlisted lasers to cool and trap atoms, and work from the late 1990s to precisely read out these atomic states. Although it was far from apparent then, these fundamental physics discoveries, and the basic science work that followed over the next two decades, now holds the promise of allowing DOD to develop a dramatically improved atomic clock device.

But the best atomic clocks operate only in lab environments—large rooms with scientists to tend their complicated laser systems. That severely limits practical applications. Still, DARPA recognized the promise that timekeeping-related advances held for military uses. So we aimed to develop simpler clock architectures based on the initial Nobel Prize research and related work that would still meet our needs.

That is much, much easier said than done, of course. After some very hard work by a very talented team, we are now developing a shoebox-sized optical atomic clock that offers dramatic reductions in size, weight, and power requirements. It aims for unheard of accuracies for a device of its size (within one billionth of a second over the course of a year). The payoffs will be huge if we are successful: secure data routing, communication systems that are insensitive to jamming, high-resolution coherent radar, and more reliable and robust global positioning. An accurate local clock would be one critical enabler of continued operation of military systems in the absence of GPS.

If successful, in combination with other technologies we are working on, this new clock developed under the QuASAR program will lead to a new set of PNT technologies—a pillar of the next generation capabilities that DARPA is building. In short, this device, along with the many other technologies we are driving, can transform war fighting for our future needs. That would be a true game-changer—and that, after all, is what DARPA is all about: changing the game in our Nation's favor.

Thank you for your support of DARPA, and for allowing me to testify before you today. I look forward to your questions.

Senator HAGAN. Thank you.

Ms. Miller.

STATEMENT OF MS. MARY J. MILLER, DEPUTY ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH AND TECHNOLOGY

Ms. MILLER. Chairman Hagan, Ranking Member Fischer, thank you for this opportunity to discuss the Army's S&T program for fiscal year 2014.

Over the course of these past 12 years of war, the world has seen firsthand the value and impact that technology brings to the battlefield and how capabilities enabled by technology are critical to the soldiers and their success.

As a recent example, research done at the Night Vision and Electronics Systems Directorate in ground-penetrating radar resulted in the Husky Mounted Mine Detection System used widely in both Iraq and Afghanistan to detect improvised explosive devices. This system is now becoming an Army program of record.

However, given the current budget environment, the Army has initiated a comprehensive strategic modernization strategy to better facilitate informed decisions based on long-term objectives. The role of the S&T enterprise is to research, develop, and demonstrate high payoff technology solutions for hard problems faced by the soldiers in ever-changing, complex environments, solutions that are both affordable and versatile.

As good stewards of the taxpayers' dollars, it is critical that we use finite Government resources to maximize development of technologies to meet Army-unique challenges and constraints. It is important that we complement what the private sector is already developing and that we leverage the work being done by our sister Services, national labs, academia, and partner nations. Most importantly, our investments today must translate into capabilities that we successfully field to the Army of the future.

It goes without saying that the underpinning of all Army S&T efforts is a strong research program that builds an agile and adaptive workforce and technology base to be able to respond to future threats. Investments in S&T are a critical hedge to acquiring technological superiority with revolutionary and paradigm-shifting technologies. This includes the development of the next generation of Army scientists and engineers. Investing wisely in people with

innovative ideas is our best hope for new discoveries to enable the Army of the future.

Thank you, and I look forward to your questions.

[The prepared statement of Ms. Miller follows:]

PREPARED STATEMENT BY MS. MARY J. MILLER

Madam Chairman, Ranking Member Fischer, and distinguished members of the subcommittee, thank you for the opportunity to discuss the Army's Science and Technology (S&T) Program for fiscal year 2014.

Over the course of these past almost 12 years of war, the world has seen firsthand the value and impact that technology brings to the battlefield and how capabilities, enabled by technology, are critical to our soldiers and their success. The U.S. Army depends on its S&T Enterprise to research, develop, and demonstrate high pay-off technology solutions for hard problems faced by soldiers in ever-changing, complex environments against an increasingly diverse set of threats. Uncertainty and complexity are at the heart of the Army's challenges. The Army of the future requires solutions that are both affordable and versatile and relies on the S&T community's contributions to ensure that they remain the most capable in the world. We are grateful to the members of this committee for your sustained support of our soldiers, your support of our laboratories and centers and your continued commitment to ensure that funding is available to provide our current and future soldiers with the technology that enables them to defend America's interests and those of our allies around the world.

To ensure our effectiveness in meeting the Army's needs, the S&T Enterprise must remain innovative and agile, staffed with scientists and engineers who can develop solutions for identified problems while understanding the constraints that Army operations require. The overarching vision for Army S&T is to foster innovation, maturation, and demonstration of technology that provides increased capability to the warfighter. Our mission includes the transition of both the understanding and knowledge acquired while developing technology solutions as well as the materiel. While the very nature of S&T puts our focus clearly on providing capabilities for the future, we continue to exploit opportunities to transition solutions to the current force.

STRATEGY

As the war in Afghanistan draws down and budgets decline, it is clear that we, the Department of Army, have some significant choices to make. We are facing an environment in which we have procured a lot of military equipment over the past decade. Systems such as the Mine Resistant Ambush Protected (MRAP) vehicles, which proved to be so valuable to saving the lives of soldiers in both Iraq and Afghanistan, will now join the ranks of the Abrams, Bradley, and Stryker as a part of our Army combat capability. The Army is assessing which urgently fielded wartime systems will come back and join the ranks of formal programs of record as a part of our enduring Army capability. These decisions will, by necessity, impact the Army strategy for future investment and research.

This is not the only impact, however. The National Military Strategy and its focus on operations in the Pacific Rim adds another level of complexity. As we expand our focus from the current fight to prepare for the future, we find ourselves in a situation where we may face a more capable enemy in an environment that is much more contested and complex. Our recent experiences, while challenging, have been against a less technically astute enemy. Our focus has been on mitigating those threats to the troops. The next fight may well be against a near-peer capability—one for which we have not fully prepared. We intend to avoid the old adage that we always prepare to fight the last war. We are investing now to understand our potential vulnerabilities and in developing capabilities that will help us be prepared for a more technically savvy opponent.

Given the current budget environment and prospects for funding in the future, it has become even more important than ever that we clearly understand our current capabilities and what we need in the future as we face ever evolving threats. With that in mind, the Army has initiated a comprehensive investment and modernization strategy to better facilitate informed decisions based on long-term objectives in a resource constrained environment.

The Army traditionally plans and budgets through the Program Objective Memorandum (POM) process. This 5 year look allows us to project with a fair level of certainty what we are doing in the next few years, but it does not lend itself well to making decisions with an understanding of how those same decisions impact the

Army of the future. The desire to look more holistically across the lifecycle of programs and to facilitate better decisions was a key driver to establishing a new process within the Department of the Army.

To that end, the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) has initiated the Long-Range Investment Analysis (LRIA) process where the Army looks out 30 years beyond the POM at the equipping and sustaining needs of the Programs of Record (PoRs). This longer-term approach covers the entire acquisition lifecycle, to include sustainment. With the renewed emphasis on assessing the impacts of near-term investment decisions on the life-cycle costs and desired capabilities of PoRs, it is increasingly important to have a sustainment strategy that is synchronized with the modernization strategy. It is essential to align S&T investments to support these PoRs and to understand where we can capitalize on opportunities for insertion of new, more affordable capability.

The LRIA feeds well into the ASA(ALT)'s desire for a more strategic modernization plan. This approach to modernization includes an awareness of existing and potential warfighting gaps, an understanding of emerging threats, knowledge of state-of-the-art commercial, academic, and government research, as well as a clear appreciation for the competing needs of limited resources.

I recognize that projections of this length are rarely accurate. However, going out 30+ years requires us to think beyond the easy answer of just doing what we are doing now but for a bit longer. It forces a new look at what else might need to happen. The world of 2040–2045 is clearly NOT going to look like the world of today. The threats we face and capabilities needed to address those threats may in fact look very different than what we have fielded today. To prepare for an uncertain future requires an approach to modernization that includes an awareness of existing and potential threats, an understanding of peer nation capabilities, knowledge of state-of-the-art commercial, academic, and government research, as well as a clear understanding of competing needs for limited resources. This is done through close collaboration with the Office of the Secretary of Defense (OSD) and the Intel Communities to not only assess foreign systems that we see under development but to conduct a technology watch that can provide indicators on what foreign countries are investigating that may become our next set of threats. This exercise challenges us to look at those eventualities.

This new way to approach our planning has put rigor into the analysis and forces the communities who pay for the development of materiel and the long-term sustainment of materiel to work together to maximize the Army's capabilities over time. From an S&T perspective, it clearly starts to inform the community as to when technology is needed for insertion as part of a planned upgrade. It also cues us as to when to start investing for replacement platforms. A great example of that is our aviation portfolio where we are conducting the S&T underpinnings of the next PoR planned to replace both the AH–64 Apache and UH–60 Blackhawk. The Army S&T community has already initiated the Joint Multi-Role Technology Demonstrator (JMR TD) effort as the foundation for the Army's Future Vertical Lift (FVL)-Medium PoR. This demonstrator program will create two flying prototypes that will help inform requirements for the FVL-Medium as well as define what should be asked for within the Request for Proposal. The S&T tech demo is being well coordinated with Program Executive Office (PEO) Aviation and the Aviation Center of Excellence at Fort Rucker to ensure that we are working a solution that will fit and inform the Army's needs.

Aside from the obvious benefit achieved by laying out the Army's programs and seeing where we may have generated unrealizable fiscal challenges, this 30 year look has reinvigorated the relationships and strengthened the ties between the S&T community and their PEO partners. We have had significant engagements over these past 7 months—working to identify technical opportunities and the potential insertion of new capabilities across this 30-year timeframe.

Goals and Commitments

There are some persistent (and challenging) areas in which the Army invests its S&T resources to ensure that we remain the most lethal and effective Army in the world. The challenges include the obvious (we need better force protection) to the less obvious (retrograde). All are consistent, however, with the message that we have gotten from the Training and Doctrine Command over the past decade. These are challenges that remain ever relevant to the Army and its ability to win the fight. The S&T community is committed to addressing these challenges which include:

- Enabling greater force protection for soldiers, air and ground platforms, and bases (e.g., lighter and stronger body armor, helmets, pelvic protection, enhanced vehicle survivability, integrated base protection)

- Ease overburdened soldiers in small units (e.g., lighter weight multi-functional material)
- Enabling timely mission command and tactical intelligence to provide situation awareness and communications in ALL environments (mountainous, forested, desert, urban, jamming, etc.)
- Reduce logistic burden of storing, transporting, distributing and retrograde of materials
- Create operational overmatch (enhance lethality and accuracy)
- Achieve operational maneuverability in all environments and at high operational tempo (e.g., greater mobility, greater range, ability to operate in high/hot environment)
- Enable ability to operate in Chemical, Biological, Radiological, Nuclear, and Explosives (CBNRE) environment
- Enable early detection and treatment for Traumatic Brain Injury (TBI) and Post-Traumatic Stress Disorder (PTSD)
- Improve operational energy (e.g., power management, micro-grids, increased fuel efficiency engines, higher efficiency generators, etc.)
- Improve individual and team training (e.g., live-virtual-constructive training)
- Reduce lifecycle cost of future Army capabilities

In addition, to these enduring challenges, the S&T community conducts research and technology that impacts our ability to maintain an agile and every ready force. This includes efforts such as establishing environmentally compatible installations and materiel without compromising readiness or training, leader selection methodologies, new test tools that can save resources and reduce test time and methods and measures to improve soldier/unit readiness and resilience.

S&T Portfolio highlights

To be able to address the needs of the Army of the future, the S&T Enterprise must maintain a balanced investment—one that ensures the growth and development of innovative S&Es and the pursuit of critical technology that will ensure the Army remains preeminent in the world. Currently the portfolio includes about 20 percent in far-term, basic research for discovery and understanding of phenomena; 40 percent in mid-term, applied research for laboratory concept demonstrations (proof of concept); and 40 percent in near-term, advanced technology demonstrations of subsystems and components in a relevant environment (experimentation).

Our S&T program request for BA1–3 for fiscal year 2014 is $2.205 billion—a 0.2 percent decrease from our fiscal year 2013 request. BA3 programs decrease by $8.6 million, BA1 programs decrease by $7.3 million and BA2 programs increase by $11.2 million.

In fiscal year 2014 the Army is placing increased emphasis in research areas to support the Army's role in the National Military Strategy, such as vulnerability assessments, Anti-Access/Area Denial (A2/AD) technologies and long-range fires. We are mindful however that the Army will continue to be called on for missions around the globe. The Army is currently deployed in ~160 countries conducting missions that range from humanitarian support to stability operations to major theater warfare.

The efforts of the S&T Enterprise are managed by portfolio to ensure maximum synergy of efforts and reduction of unnecessary duplication. There are currently six portfolios. Three are platform specific portfolios: Soldier, Ground, Air; the other three are enabling technology portfolios: C^3I, Innovation Enablers, and Basic Research. Each affords the Army with unique capability. To facilitate this broad spectrum of capabilities, we are creating a culture of affordability and from a technology perspective have increased our focus on reducing lifecycle costs.

SOLDIER PORTFOLIO

The soldier portfolio is broad in nature—it extends from research in enhancing soldier performance to improved soldier equipment to new medical treatments. This portfolio touches all of the challenges listed above in some capacity. Focus areas include achieving technical advances based on future threats and environments in force protection, lethality, mobility, leader development, training, combat casualty care and rehabilitation medicine, as well as psychological and physical health treatments. In fiscal year 2014 we are requesting $376.7 million for our soldier portfolio.

The efforts in this portfolio are designed to address future threat environments while maximizing the effectiveness of Squad performance as a collective formation. They result in state of the art changes to equipment and training tools and inform

changes to policies, personnel selection and classification, and individual and collective training.

Major initiatives include the integration of lethality assets, individual protection, and dismounted soldier power. In the coming years, improving mission performance in a complex and dynamic environment will rely on improving the integration of cognitive and physical performance with emerging technology solutions leading to the advancements necessary to reduce the soldier's load. Successful recent efforts include a collaborative effort with PEO soldier to improve the form and fit of the Improved Outer Tactical Vest (IOTV) for female soldiers. The existing IOTV designs were cut for a standard male and impeded the ability for female soldiers to operate weapons and equipment effectively. The S&T community assessed the needs of the female soldiers and as a result developed better waist and torso adjustment straps and less bulky collar and throat protection.

In keeping with our holistic approach to Army challenges, research will address the entire chain of services and technologies which touch our soldiers and squads from pre-deployment to mission capabilities needed on the battlefield to their return to civilian life. Pre-deployment and return to civilian life research includes important areas such as Post Traumatic Stress Disorder (PTSD) and Traumatic Brain Injury (TBI) which continue to be a source of serious concern. The U.S. Army Medical Research and Materiel Command (MRMC) has ongoing efforts to address these devastating conditions. Basic research efforts include furthering our understanding of cell death signals and neuroprotection mechanisms, as well as identifying critical thresholds for secondary injury comprising TBI. When cells die they release signals in the form of proteins. These proteins can be measured using different biological assays, which can tell you what type of response a cell has mounted against different types of injuries to include TBI, so you can quantify the level of injury.

We are also focused on investigating selective brain cooling and other nontraditional therapies for TBI, and identifying "combination" therapeutics that substantially mitigate or reduce TBI-induced brain damage and seizures for advanced development and clinical trials. We have had some recent successes in this area, including completion of a Food and Drug Administration effectiveness study on a candidate neuroprotective drug for treatment of TBI and completion of a pivotal trial for a bench-top assay for use in hospitals for the detection of TBI.

Research in the area of personnel selection, classification and training must also be looked at in light of future threats and evolving mission scenarios such as cyber and robotic interactions. Technologies which support future mission capabilities needed on the battlefield include efforts to reduce chronic conditions which may result from load-related injuries. Material and equipment design efforts focus on innovative decision and mission planning tools and the integration of individual and squad weapons, weapon sights, munitions and fire control while mitigating cognitive and physical burden on the increasingly complex battlefield. Finally, we are working on new materials and modular armor designs to optimize individual protective equipment to fully consider survivability in relation to mobility, lethality, and other aspects of human performance. This work is aligned with PEO soldier's planned Soldier Protection Systems PoR which affords many opportunities for technology transition out of the S&T community.

GROUND PORTFOLIO

The Ground portfolio includes technologies for medium- and long-range munitions and missiles; directed energy weapons; combat and tactical vehicle; unmanned ground systems; countermine and counter Improvised Explosive Devices (IED) detection and neutralization; and base protection technologies. As with the soldier portfolio, the ground portfolio addresses a number of the Army's enduring challenges including force protection, improved mobility and overmatch, increased operational energy and reduced life cycle costs. In fiscal year 2014 we are requesting $607.1 million for our Ground Portfolio.

The Ground Portfolio has shifted to focus on developing A2/AD through Long-Range Fires and Counter Unmanned Aircraft technologies. S&T is focusing on advanced seeker technologies to enable acquisition of low signature threats at extended ranges, along with dual pulse solid rocket motor propulsion to provide longer range rockets and extend the protected areas of air defense systems. We also continue to develop Solid State High Energy Lasers to provide low cost defeat of rockets, artillery, mortars, and unmanned aircraft.

Also as part of A2/AD, we have increased funding for evaluation of austere ports of entry and infrastructure to better enable our ability to enter areas of conflict. We are maintaining technology investments in detection and neutralization of mines and improvised explosive devices (IED) to ensure freedom of maneuver.

In the past, we have designed vehicles with little consideration for accommodating soldiers who have to operate in them. Now we are beginning to explore ways to design vehicles around soldiers. Increasing protection levels of the platforms means impacting interior volumes reducing mobility, maneuverability, and freedom of movement for occupants, and leads to heavier platforms. The ongoing Occupant Centric Survivability (OCS) effort provides the mechanism to develop, design, demonstrate, and document an occupant centered Army ground vehicle design philosophy that improves vehicle survivability, as well as force protection, by mitigating warfighter injury due to underbody IED and mine blast, vehicle rollover, and vehicle crash events. This design philosophy considers the warfighter first, integrates occupant protection technologies, and builds the vehicle to surround and support the warfighter and the warfighter's mission. To this end, we are developing an OCS concept design demonstrator, as well as, platform-specific demonstrators with unique occupant protection technologies tailored to the platform design constraints. Subsystems and components designed and evaluated by this effort may transition to current and future ground vehicle Programs of Record. This focused effort will facilitate the development and publication of standards for occupant centric design guidelines, test procedures and safety specifications.

Armor remains an Army-unique challenge and we have persistent investments for combat and tactical vehicle armor, focusing not only on protection but affordability and weight. We continue to invest in armor technologies to meet the Ground Combat Vehicle's (GCV) objective protection requirements. Armor formulations developed at the Army Research Lab (ARL) and matured at the Tank Automotive Research Development and Engineering Command have transitioned and been offered to the GCV vendors. In addition to the continued emphasis on lighter, more capable armor solutions, we are beginning to develop an architecture standard to enable the integration of active protection technologies onto ground vehicles, reducing the need for as much heavy armor plating.

We continue to develop technologies to increase available power to ground vehicles and improve fuel efficiency. Additionally, we are maturing architecture standards to manage electrical power and data, providing industry a standard interface for integrating communications and sensor components to ground vehicles.

AIR PORTFOLIO

The Army is the lead service for rotorcraft, owning and operating over 80 percent of the Department of Defense's vertical lift aircraft. As such, the preponderance of rotorcraft technology research and development takes place within the Army. The Air portfolio addresses many of the same challenges as the ground portfolio and its key initiative, the JMR TD program, is focused on addressing the A2/AD need for longer range and more effective combat profiles. Our vision for Army aviation S&T is to provide the best possible aviation technology enabled capabilities to deliver soldiers, weapons, supplies, and equipment where they are needed, when they are needed. For fiscal year 2014 we are requesting $162.6 million for our Air Portfolio.

In order to provide soldier support over future Areas of Operation (AO) that may be 16 times larger than current AOs, the Army needs a faster, more efficient rotorcraft, with significantly improved survivability against current and future threats. Operating in conditions of 6,000 feet and 95 degrees (high/hot), this aircraft will need to transport and supply troops while providing close air support and intelligence, surveillance, and reconnaissance capabilities.

As I mentioned before, a major effort currently underway within S&T is technology development for the Department of Defense's next potential "clean sheet" design rotorcraft—the JMR aircraft. Three different configurations of JMR aircraft have been designed—a conventional helicopter, a large-wing slowed rotor compound helicopter, and a tilt rotor helicopter. We are investigating various design excursions to fully explore the size and environmental characteristics of interest to the DOD including shipboard operations. As part of the JMR TD program, an industry/government Configuration Trades and Analysis effort (including Operations Analyses to assess concept effectiveness), is nearing completion. Four contracts were competitively awarded to assist in defining the trade space for Phase 1 of the JMR TD, Air Vehicle Demonstration. Two of the contractors will be downselected for the Phase 1 awards in September 2013, which will include the design, fabrication, and test of two flight demonstrator vehicles, with first flights to occur in the fourth quarter of fiscal year 2017. The JMR TD objectives are to validate critical aircraft configurations, technologies and designs at the vehicle system level, and demonstrate vertical lift capabilities superior to those in the current fleet. Phase 2 of the JMR TD is focused on assessing Mission Systems Effectiveness. Six contracts have been awarded

to conduct these trades. The overall JMR TD effort will use integrated government/industry platform design teams and exercise agile prototyping approaches.

One of the biggest causes of aircraft loss comes from accidents while operating in a Degraded Visual Environments (DVE). To address this, we are currently conducting a synchronized, collaborative effort with PEO Aviation and the S&T community to define control system, cueing, and pilotage sensor combinations which enable maximum operational mitigation of DVE. This effort will result in a prioritized list of compatible, affordable DVE mitigation technologies, and operational specification development that will help inform future Army decisions. This program is tightly coupled with the PEO Aviation strategy and potential technology off-ramps will be transitioned to the acquisition community along the way, when feasible.

Unmanned systems have a potentially broad impact on how the Army conducts close air support. Army S&T is focused on improving the capability of unmanned systems to be a force multiplier through the introduction of unmanned and teaming operations technologies with the potential to offer game changing future capabilities. Efforts include advancing human systems interface and algorithms for synergistic and intelligent manned unmanned teaming, and image/data processing algorithms to allow objective driven perception. In fiscal year 2014 we plan to initiate a new applied research program to develop micro/small scale unmanned air systems. This new effort will allow for the transition of technology from the Micro-Autonomous Systems Technology Collaborative Technology Alliance basic research effort.

While many of our rotorcraft research efforts are focused on the development of technology for transition to new platforms in 2025 and beyond, we are also maintaining an investment to keep the current fleet effective. One recent transition success has been the Advanced Affordable Turbine Engine (AATE), a 3,000 shaft horsepower engine with 25 percent improved fuel efficiency, and 35 percent reduced lifecycle costs. In fiscal year 2013, final bench testing will be completed and the AATE program will transition to PM Utility for Engineering and Manufacturing Development under the Improved Turbine Engine Program, which will re-engine our Blackhawk and Apache fleet.

C^{3}I PORTFOLIO

The C^{3}I portfolio provides enabling capability across many of the challenges, but specifically seeks to provide mission command and tactical intelligence—working to ensure soldiers from the sustaining base to the tactical edge have trusted and responsive sensors, communications, and information adaptable in dynamic, austere environments to support battlefield operations and non-kinetic warfare. For fiscal year 2014 we are requesting $320.0 million for our C^{3}I Portfolio.

New efforts in this portfolio include development of secure wireless personal area networks for the soldier. We are also re-investing in Electronic Warfare (EW) vulnerability analysis to perform characterization and analysis of radio frequency devices to develop detection and characterization techniques, tactics, and technologies to mitigate the effects of contested environments (such as jamming) on Army C^{4}ISR systems.

Given the potential challenges that we face while operating in a more contested environment, we are placing additional emphasis in assured Position, Navigation and Timing, developing technologies that allow navigation in Global Positioning System (GPS) denied/degraded environments for mounted and dismounted soldiers and unmanned vehicles such as exploiting signals of opportunity. Improvements will be studied for high sensitivity GPS receivers that could allow acquisition and tracking under triple tree canopy, in urban locations, and inside buildings, which is not currently possible. We are developing an Anti-Jam capability as well as supporting mission command with interference source detection, measurement of signal strength, and locating interference sources, enabling the Army to conduct its mission in challenging electromagnetic environments.

The C^{3}I Portfolio also houses our efforts in cyber, both defensive and offensive. Defensive efforts in cyber security will investigate and develop software, algorithms and devices to protect wireless tactical networks against computer network attacks. Effort includes technologies that are proactive rather than reactive in countering attacks against tactical military networks.

We are developing sophisticated software assurance algorithms to differentiate between stealthy life cycle attacks and software coding errors and design and assess secure coding methodologies that can detect and self correct against malicious code insertion. We are also investigating theoretical techniques for improvements in malware detection that can detect malware variants incorporating polymorphic and metamorphic transformation engines. We will research and design sophisticated, optimized cyber maneuver capabilities that incorporate the use of reasoning, intuition,

and perception while determining the optimal scenario on when to maneuver, as well as the ability to map and manage the network to determine probable attack paths and the likelihood of exploitation. Additionally we will investigate dynamically and efficiently altering tactical network services, ports, protocols and systems to inhibit red force ability to perform malicious network reconnaissance to determine location of critical networking services.

On the offensive side of cyber operations, we will develop integrated electronic attack (EA) and computer network operations (CNO) hardware and software to execute force protection, EA, electronic surveillance (ES) and signals intelligence missions in a dynamic, distributed and coordinated fashion, resulting in the capability to engage a multitude of diverse multi-node, multi-waveform, multi-platform and cyber (internetworked computers) targets while maximizing overall network efficiency and effectiveness, and preserving blue force/noncombatant communications.

We will demonstrate protocol exploitation software and techniques that allow users to remotely coordinate, plan, control, and manage tactical EW and Cyber assets; develop techniques to exploit protocols of threat devices not conventionally viewed as Cyber to expand total situational awareness by providing access to and control of adversary electronic devices in an area of operations.

INNOVATION ENABLERS

The Innovation Enablers portfolio includes many of the activities that are not directly tied to programs of record, yet enable the Army to be successful. It is within this portfolio that we conduct the research that helps to ensure that we have training ranges upon which our soldiers can train as they fight, support our High Performance Computing Centers which facilitate highly complex research and system design, and conduct Technology Maturation Initiatives that partner the S&T community directly with PEOs to conduct experimentation that not only informs realistic requirements but also drives down programmatic risk. For fiscal year 2014 we are requesting $302.0 million for our Innovation Enablers Portfolio.

Under this portfolio we focus on many of those technologies which, while not specific to warfighter functions, are essential to ensuring that warfighters can conduct their missions. As the largest land-owner/user within the DOD, it is incumbent upon the Army to be good stewards in their protection of the environment. Within this portfolio, we develop and validate lifecycle models for sustainable facilities; create dynamic resource planning/management tools for contingency basing; develop decision tools for infrastructure protection and resiliency; and assess the impact of sustainable materials/systems This includes the development of geo-environmental intelligence/advanced sensing capabilities and predictive computational tools for fate, transport and effects of existing and emerging chemicals and materials used by the Army as well as new formulations for munitions and obscurants that have minimal environmental impacts. We also focus on developing sustainable and environmentally friendly practices that not only reduce or eliminate soldier exposure to hazardous and carcinogenic materials but also minimize environmental impacts during maintenance and depot activities such as painting and plating.

In addition, we conduct blast noise assessment and develop mitigation technologies to ensure that we remain "good neighbors" within Army communities and work to protect endangered species while we ensure that the Army mission can continue. Ensuring current and future use of the Army's training ranges will become even more important as they will be where soldiers get their experience, vice deployment in theater. As a result, we are even developing planning and response tools to determine impacts on mission critical natural infrastructure and adaptable training land configuration technologies to ensure our soldiers are given maximum access to training ranges and lands. This supports the Army's ability to address evolving mission requirements while protecting our current resources.

BASIC RESEARCH

Underpinning all of our efforts and impacting all of the enduring Army challenges is a strong basic research program. The vision for Army basic research is to advance the frontiers of fundamental science and technology and drive long-term, game-changing capabilities for the Army through a multi-disciplinary portfolio teaming our in-house researchers with the global academic community. For fiscal year 2014 we are requesting $436.7 million for Basic Research.

Two high pay-off areas of research investment are Neuroscience and Materials Science. Neuroscience is a high priority research area—understanding the brain's structure and function is a top foundational research theme for the Obama administration and the National Academies. The Army is leveraging the opportunities afforded by the large medical research base in neuroscience to move neuroscience from

the bench to the battlefield. Making this transition will enable a broad range of scientific discoveries that fundamentally shift how we understand how the brain (and thus soldiers) works.

A new area of promising research is our effort in Multi-scale Modeling of Materials. The goal of this research is to realize the capability to design materials at the atomic level to provide the exact properties we need for an end product. In other words, we plan to demonstrate a comprehensive "materials by design" capability for electronic and protection materials. The pay-off could be protection materials with one-third savings in weight of current systems, and batteries with triple the energy density, 30 percent longer lifetimes, and 20–30 percent more efficiency all at a lower cost.

Another new area of basic research investment in fiscal year 2014 is Cyber Security, where we are standing up a Cyber Security Collaborative Research Alliance (CRA), a competitively selected consortium, to advance the theoretical foundations of cyber science in the context of Army networks. This CRA consists of academia, industry and government researchers working jointly with the objective of developing a fundamental understanding of cyber phenomena so that laws, theories, and theoretically grounded and empirically validated models can be applied to a broad range of Army domains, applications, and environments. The overarching goals of cyber security are to significantly decrease the adversary's return on investment when considering cyber attack on Army networks, and minimizing the impact on Army network performance related to implementing cyber security. The CRA research creates a framework that effectively integrates the knowledge of cyber assets and potential adversary capabilities and approaches, and provides defense mechanisms that dynamically adjust to changes related to mission, assets, vulnerability state, and defense mechanisms.

We had a number of technology spin-offs and transitions from basic research this past year. An example is in Helmet Mounted Displays. A researcher from the Institute for Creative Technologies, an Army funded University Affiliated Research Center, created a game-changer in the world of virtual reality (VR) headsets by providing a 3–D, wide field of view, tracking enabled VR headset at a cost of $300 (in contrast to an Army Helmet Mounted Display device that costs $70,000). The VR device called Oculus Rift won Wired Magazine's best of the Consumer Electronics Show (CES) 2013 and the Electronic Entertainment Expo (E3) best of award. Oculus Rift disrupts the supply chain and creates the option for a low cost tool developed by Army-sponsored research that the Army will leverage for training. The hope is that the Oculus Rift will be the first of many commercial applications that will be incorporated into our Army systems—increasing competition and decreasing costs.

CROSS-PORTFOLIO ACTIVITIES

Across all of our portfolios, we maintain our focus on power and energy. As we develop technology enabled capabilities, we work to reduce the burden in both weight and logistics that comes from increased energy consumption by the increasing amount of electronic equipment we need in our operations. The Army modernization investment in operational energy provides efficient, reliable and maintainable systems that increase capabilities and maintain dominance. Our objectives are to improve efficiency and reduce consumption while increasing functionality and developing smart energy-saving designs. Our existing programs are integrated with, and complementary to, the operational energy strategy of the Assistant Secretary of the Army for Installations, Energy, and the Environment. In the fiscal year 2014 budget request we have, interspersed among our portfolios, $145.3 million for power and energy projects, in addition to efforts such as efficient vehicle design and light weight materials which also impact the Army's energy usage.

The Army continues to make use of the Rapid Innovation Fund, established by Congress in fiscal year 2011. We are currently funding 48 efforts in a variety of areas and have an additional 43 proposals under review. I believe that this initiative is providing value to the Army and opening up more collaborative opportunities for small and nontraditional businesses, and we plan to solicit further proposals for fiscal year 2013 in the near future.

The Army Small Business Innovation Research Program (SBIR) program is another way the Army gets access to innovative ideas and products. The SBIR program is designed to provide small, high-tech businesses the opportunity to propose innovative research and development solutions in response to critical Army needs. In fiscal year 2011, the Army SBIR office generated 139 topics based on inputs from laboratories, the Army Training and Doctrine Command and the Program Executive Officers (PEO). In response to these topics, small businesses submitted over 3000 proposals. The Army SBIR office approved more than 600 Phase I and Phase II

awards. Since 2000 there have been 575 Phase III Army SBIR projects put under contract for a total obligated value of $1.4 billion (Phase III SBIRs are Phase II projects that have been picked up by either the government (PEO/PM) or industry).

THE S&T ENTERPRISE WORKFORCE

Without the world-class cadre of over 12,000 scientists and engineers and the infrastructure that supports their work, the Army S&T enterprise would be unable to support the needs of the Army. To maintain technological superiority now and in the future, the Army must maintain an agile workforce. Despite this current environment of unease within the government civilian workforce, I'm proud to say that in 2012, the Army was recognized by Thompson Reuters as one of the Top 100 Global Innovators, with over 300 patents documented in the previous 3 years. We have an exceptional workforce. But we must continue to attract and retain the best science and engineering talent into the Army Laboratories and Centers and this is becoming more and more challenging. Our laboratory personnel demonstrations give us the flexibility to enhance recruiting and afford the opportunity to reshape our workforce, and I appreciate Congress' continued support for these authorities. With one exception (the Army Research Institute (ARI) for the Behavioral and Social Sciences), all of our laboratories and centers are operating under this program (ARI was never designated a Science and Technology Reinvention Laboratory and given its small size, has not sought to enter into a demo system). These initiatives are unique to each laboratory, allowing the maximum management flexibility for the laboratory directors to shape their workforce and remain competitive with the private sector.

In terms of infrastructure, we completed a survey of our laboratory infrastructure and find that it is aging, with an average approximate age of 50 years. However, we do acknowledge that much of the Army is in a similar position. Despite this, we continue to make improvements to our infrastructure at the margins, and where possible we have used military construction, through your generous support, Defense Base Realignment and Closure Commission, and unspecified minor construction to modernize facilities and infrastructure. This is not a long-term solution. While the authorities that you have given us have been helpful, they alone are not enough, and we are still faced with the difficulty of competing within the Army for scarce military construction dollars at the levels needed to properly maintain world-class research facilities. This will be one of our major challenges in the years to come and I look forward to working with OSD and Congress to find a solution to this issue.

Army S&T enterprise cannot survive without developing the next generation of scientists and engineers. We are lucky to have an amazing group of young scientists and engineers to serve as role models for the next generation. Last year, Dr. Maria Urso, a researcher at the U.S. Army Research Institute of Environmental Medicine's Military Performance Division at Natick Soldier System's Center in Natick, MA, was named by President Obama as one of the Nation's Outstanding Early Career Scientists. She received the award for her scientific contributions in the area of cellular mechanisms of musculoskeletal injury and repair and for her incredible service to both military and civilian communities. The Presidential Early Career Awards for Scientists and Engineers are the highest honor bestowed by the U.S. Government on science and engineering professionals in the early stages of their independent research careers, and we are lucky to have researchers like Dr. Urso to mentor the next generation.

The Army S&T Enterprise contributes to the future success in Science, Technology, Engineering, and Math (STEM) education through the Army Educational Outreach Program (AEOP) which is comprised of 17 outreach efforts, either through direct oversight or through active participation. In the 2011–2012 academic year AEOP was able to place less than half of the student online applicants, engaged nearly 53,000 students as well as 835 teachers, involved 17 Army laboratories or installations, and 111 universities or colleges and utilized the experience and personal commitment from many of our Army scientists and engineers. Mostly executed under the Army Educational Cooperative Agreement (COA) which brings together government and a consortium of organizations working collaboratively to further STEM education and outreach efforts nationwide, AEOP provides a cohesive and coordinated approach to STEM education across the Army. Major accomplishments in fiscal year 2012 included ongoing annual in-depth evaluative assessments of seven programs and recommendations for evidence-based program improvements. We completed a marketing campaign that centralized all the individual programs into a single branding to leverage resources as well as promote a continuation of Army STEM experiences that work together to build a highly competitive STEM literate talent

pool for Army scholarship and workforce initiatives. We continue to enhance the online, comprehensive application tool located on the AEOP website which will be complete in fiscal year 2013. The application tool will provide important data that assess attitudes, motivation, qualifications, and experiences that gauge program effectiveness. The website and the online application tool as well as the COA will work together to provide a coherent and coordinated approach to address the STEM workforce shortfall throughout the Army. For fiscal year 2014, we are concentrating on further program assessment, implementing evidence-based program improvements, strengthening additional joint service sponsored efforts, and identifying ways to expand the reach and influence of successful existing programs by leveraging partnerships and resources with other agencies, industry and academia.

Finally, we are increasingly mindful of the globalization of S&T capabilities and expertise. Our International S&T strategy provides a framework to leverage cutting edge foreign science and technology enabled capabilities through Global S&T Watch, engagement with allies and leadership initiatives. Global Science and Technology Watch is a systematic process for identifying, assessing, and documenting relevant foreign research and technology developments. The Research, Development and Engineering Command's International Technology Centers (ITCs) and Medical Research Materiel Command's OCONUS laboratories identify and document relevant foreign S&T developments. We also selectively engage our allies when their technologies and materiel developments can contribute to Army needs and facilitate coalition interoperability. These bilateral leadership forums with Israel, Canada, Germany and the United Kingdom provide both visibility of and management decisions on allied developments that merit follow-up for possible collaboration.

SUMMARY

The underpinning all of Army S&T efforts is a strong research program that builds an agile and adaptive workforce and technology base to be able to respond to future threats. Investments in S&T are a critical hedge in acquiring technological superiority with revolutionary and paradigm-shifting technologies. This includes the development of the next generation of Army Scientists and Engineers.

Investing wisely in people with innovative ideas is our best hope for new discoveries to enable the "Army of the Future."

In this fiscally constrained environment, we will emphasize S&T areas that address truly Army-unique challenges and leverage everything else. We will collaborate across the Services, National Labs, academia, industry and partner Nations, to solve common challenges. As good stewards of the taxpayers' dollars, it is critical that we use finite government resources to maximize development of technologies to meet Army-unique challenges and constraints, and it is important that we complement what the private sector is already developing. Most importantly, our investments today must translate into capabilities we successfully field to the Army of the future.

As the ASA(ALT) said in her February 28, 2013 testimony to the House Armed Services Committee on Sequestration " . . . the Army will provide soldiers with the best equipment available as needed; their sacrifice deserves no less. All equipping programs and priorities will be negatively affected by the application of sequestration. Likewise the defense industrial base will be adversely impacted and critical skill sets will be lost." These words apply equally to the Army's S&T program—forcing us to take a hard look at our investments and undoing much of the work that we have set in place to increase our efficiencies.

This is an interesting, yet challenging, time to be in the Army. Despite this, we remain an Army that is looking towards the future while taking care of the soldiers today. I hope that we can continue to count on your support as we move forward, and I would like to again thank the members of the committee again for all you do for our soldiers. I would be happy to take any questions you have.

Senator HAGAN. Thank you.

Ms. Lacey.

STATEMENT OF MS. MARY E. LACEY, DEPUTY ASSISTANT SECRETARY OF THE NAVY FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION

Ms. LACEY. Good afternoon, Madam Chairman Hagan, Ranking Member Fischer. It is an honor to appear here today before you to discuss the Navy's research and development (R&D) enterprise.

In the year since I last appeared, we as a department have performed an extensive strategic review of our RDT&E resources, and the Secretary has established a corporate board to provide strategic oversight to our RDT&E investments and priorities and to further embed into our day-to-day business the urgency and flexibility we honed during a decade of a wartime posture.

Sequestration decreases our RDT&E accounts $1.5 billion in fiscal year 2013. This impacts all 282 program elements within the account. In S&T, we expect to place 300 less grants and cancel up to half of our new start functional naval capability projects. In development, we will delay most programs by about 3 months.

The Navy has historically made deliberate and measured investments to ensure stability and the right capacity within the organic technical workforce. Section 219 of the 2009 National Defense Authorization Act (NDAA) has proven invaluable to maintaining the health of our Navy labs, warfare, and systems centers. The Navy has used section 219 authority to refresh the technical capabilities of our workforce while enabling innovation. We are also placing greater emphasis on technical discipline on approaches that change the cost equation with things such as automated testing, open architecture, and corrosion prevention.

Investment in our workforce is critical, but it must be coupled with an appropriate investment in infrastructure. Based on the direction of this subcommittee, the Navy has expanded our ongoing test and evaluation infrastructure capabilities look to include our R&D enterprise. We are about halfway completed in our initial data gathering and we will use that in the future to make some strategic investment in our facilities.

In these exceptionally challenging technological and budgetary times, our goal continues to be to provide our sailors and marines with technically superior capabilities. We can ensure this through disciplined processes focused on affordability executed by a skilled workforce with technical capabilities second to none.

Thank you very much. I look forward to your questions.

[The prepared statement of Ms. Lacey follows:]

PREPARED STATEMENT BY MS. MARY E. LACEY

INTRODUCTION

Madam Chairman and distinguished members of the subcommittee, it is an honor to appear before you today to report on the efforts of the Department of Navy (DON) Science and Technology (S&T) Laboratory Enterprise. Its ultimate goal is to develop and rapidly deliver innovation to our warfighters more efficiently through the effective use of the technological resources of our Nation within the commercial sector, Federally Funded Research and Development Centers (FFRDCs), University Affiliated Research Centers (UARCs), and our Naval Laboratories and Warfare Centers.

The military dominance of the United States and U.S. Naval Forces in particular, is closely coupled to technical superiority of our military equipment and systems. With the future budget challenges we must continue to encourage the creativity of our scientists and engineers to meet the challenges of our adversaries while focusing on the affordability of our current and future weapon systems and platforms. I would like to thank the committee for your continued support of our Nation's science and engineering base who continue to provide new and improved affordable warfighting capabilities to sustain the technology leadership our sailors and marines enjoy.

In the year since I last appeared before you the DoN has performed an extensive strategic review of our research, development, test, and evaluation (RDT&E) resources to move the possibilities offered by science and technology into practical applications executed through engineering to benefit our Navy and Marine Corps. This

includes ongoing reviews of the RDT&E accounts; focused efforts by DoN leadership to accelerate game-changer technologies into fieldable systems, collaboration with the Assistant Secretary of Defense for Research and Engineering on efforts to improve communications and collaboration between the Industrial base and our technical community through the Defense Innovation Marketplace, and ongoing efforts of the Naval Laboratory Center Coordinating Group (NLCCG) to invest in the technical capabilities of in-house technical workforce and their critical infrastructure. The technological threats to the Navy and Marine Corps are constantly changing. The anti-access/anti-denial (A2/AD) capabilities of our potential adversaries are one example of the constantly changing threat environment that impacts the ability of our forces to maintain technological superiority. The Navy has come a long way over the last few years in achieving balance in our technical workforce and infrastructure to ensure technical capabilities critical to the Navy are maintained in our Naval Laboratories and Warfare Centers. There still remain many significant challenges, including an examination of how best to utilize FFRDCs and UARCS to address the challenges ahead but we continue to make strides in understanding the full strategic potential of our national resources to affordably deliver game changing technologies to the DoN.

Strategic reviews

To ensure the future technological superiority of our Fleet and Force it is critical that prudent DoN RDT&E investments provide combat effectiveness, affordability and improved reliability and maintainability in our current and future weapon systems. With increasing fiscal pressure, it is imperative that the DoN ensure its RDT&E investments: target the correct warfighter missions, are aligned across all RDT&E accounts, and expeditiously transition required technologies to Fleet and Force operators.

The RDT&E Corporate Board provides governance of the Department of the Navy's (DoN) RDT&E investments and activities of RDT&E (Budget Activity 1–7) portfolios, programs, and priorities. It will ensure the Department's RDT&E budget and execution decisions support near- and long-term acquisition programs. Additionally, the Corporate Board provides advice and assistance in developing policies for rapid technology transition by reviewing transition processes that move S&T projects into acquisition RDT&E programs of record, including Rapid Fielding Efforts (e.g., CNO Speed-to-Fleet).

We have recently initiated our second rounds of review of DoN RDT&E investments. Our focus is to ensure we are effectively balancing tactical and strategic requirements against our current and future technical capabilities. We want to shift our decisions from reactive and stovepiped to a broader holistic approach where decisions are made at the appropriate level to ensure the wisest use of our resources and intellectual capital. Through the rigor of review, the DoN is looking for game changers. These are innovations that effectively integrate technology with policy and business to deliver real solutions for our sailors and marines. The basic concepts of Integration and Interoperability cause us to look across the kill-chain to see how systems really work together.

From these reviews, we will have some tactical course corrections that will properly align RDT&E projects in a more accurate budget activity. With the RDT&E investments properly characterized, the RDT&E Corporate Board can start to address the strategic direction of the appropriation to foster sharing of technological developments across warfare areas; orderly transition of innovation (e.g., disruptive technologies); and future business/policy/technology game changers like Open Architecture and Automatic Test and Re-Test. Two current areas of emphasis in the RDT&E portfolio are directed energy weapons and non-acoustic anti-submarine warfare.

Directed energy weapons offer the Navy game-changing capability in terms of speed-of-light engagement, deep magazines, multi-mission functionality and affordable solutions. High-energy laser weapons are extremely affordable due to their very low engagement costs (low cost per shot), which is critical in the current fiscal environment. High energy laser weapons are capable of deterring asymmetric threats, including swarming small boats, UAVs, and other low-cost, widely available weapons. The Navy continues to invest in rapid fielding initiatives and technical demonstrations to introduce these new technologies to the Fleet and develop future capabilities. The Navy maintains a broad portfolio of directed energy weapons programs comprising shipboard, airborne, and ground-based systems. Recent Navy investments in laser technology includes the first high-energy laser aboard a moving Navy surface combatant, the Maritime Laser Demonstration; the Mk38 Tactical Laser System also demonstrated against small boats as well as other targets; while the LaWS (Laser Weapon System) demonstration successfully countered remotely piloted drones from USS *Dewey* in 2012. As part of a CNO-directed demonstration

program, the Navy intends to install a prototype LaWS aboard USS *Ponce* (AFSB 1), which is currently forward deployed to the 5th Fleet AOR. This demonstration, which will begin in fiscal year 2014, is the latest in a series of technical maturation efforts designed to provide an operational laser to the fleet.

A key to future Navy warfighting capabilities is the rapid development, prioritization, and deployment of Non-Acoustic Anti-Submarine Warfare capabilities. This can be accomplished through efficient technology transitions, acquisition, and management across the Navy Enterprise and coordination with the U.S. Intelligence Community. Aside from the development and fielding of Non-Acoustic Anti-Submarine Warfare capabilities and/or systems, the DoN must also plan for the employment of these same types of capabilities by our adversaries. The DoN must be cognizant of this emerging threat and must understand the operational vulnerabilities and thus guide the development of mitigation strategies and capabilities.

Workforce and Infrastructure

As the Deputy Assistant Secretary of the Navy for Research, Development, Test, and Evaluation, I have oversight responsibility to the Assistant Secretary of the Navy for Research, Development, and Acquisition for all RDT&E accounts, systems engineering and overall stewardship responsibilities for the Naval Laboratories and Warfare Centers. The DoN has 15 activities that compose the In-house research and development capacity. It is comprised of the Naval Research Laboratory (NRL) and 14 Warfare and Systems Centers aligned to 3 Systems Commands: Naval Sea Systems Command (NAVSEA), Naval Air Systems Command (NAVAIR), and Space and Naval Warfare Systems Command (SPAWAR). The Navy's principal Laboratory, the Naval Research Laboratory (NRL) was created by Congress in 1923. Over half of the work NRL performs is fundamental science and technology, nearly all in partnership or in collaboration with academia and researchers in other government laboratories and activities. The Warfare and Systems Centers, while being involved in basic science, play most strongly in technology and engineering, often in partnership with industry, and government program offices. They too have long histories, some dating back to the 1800s, and were created to respond to a specific threat or technological challenge. The NLCCG is our principal coordinating body for our in-house activities. The group has been very active over the last year in meeting the challenges I set before them to define core technical capabilities and to determine how to optimally integrate all these capabilities to meet the affordability challenges of today's platform and systems acquisition while planning integrating and delivering transformational technologies for the Navy-After-Next. Their focus was to:

- Align processes for the work we accept from customers;
- Establish common processes for measuring the technical health of our workforce;
- Establish Department of Navy wide definitions for core capabilities and competencies; and
- Ensure consistency and transparency in program costing practices to ensure we make every dollar count within the Navy Working Capital Fund model.

The Naval Laboratories and Warfare Centers constitute a diverse, highly skilled workforce of over 43,000 employees with over 24,000 scientists and engineers. Among the scientists and engineers over 8,000 hold advanced degrees in science, engineering, or mathematics. The Navy continues its efforts to revitalize and maintain the technical capabilities of the acquisition workforce by hiring over 2,000 technical personnel at the Warfare centers in the technical career fields of Systems Planning, Research, Development and Engineering, Test and Evaluation (T&E), Information Technology (IT) and Production, Quality, and Manufacturing.

The DON DT&E Self-Assessment Report for 2012 showed that our T&E workforce continues to be adequately structured to support the needs and demands of our acquisition programs. Continuous process improvement efforts resulted in significant gains this past year for our T&E workforce with slight growth in numbers, continuation of organizational alignment efforts, enhanced T&E training opportunities and enhanced T&E awards. At the leadership level, DON continues to use the Gate review process to monitor the activities and progress of acquisition programs, to include T&E. Naval Systems Commands and affiliated Program Executive Offices/Program Management Offices continue to structure their organizations to meet workload demands and provide for the overall T&E competency expertise. DON continues to work close with the Office of the Secretary of Defense (OSD) to address acquisition reform initiatives, workforce improvement efforts, and T&E efficiency and effectiveness mandates.

The Department of Navy was honored to receive the 2012 Top 100 Global Innovator Award from Thomson Reuters which identified the Navy as one of the world's

most innovative organizations. The Navy was the top ranked government organization granted this award that is based on the objective criteria of overall patent volume, patent grant success rate, global reach of the portfolio and patent influence as evidenced by citations. In addition the Navy continues to be recognized by the Institute of Electrical and Electronics Engineers and the industry based Intellectual Property Intelligence Quotient patent board as a top 10 performer in innovation worldwide.

Section 219

The DoN has historically made deliberate and measured investments to ensure stability within the organic workforce. During this period of refreshing our workforce, section 219 of the NDAA for Fiscal Year 2009 has proven invaluable to maintaining the health of the Navy Labs, Warfare and Systems Centers. The Naval Innovative Science and Engineering (NISE) program grew to nearly $100 million in fiscal year 2012. The NISE investments have been critical in refreshing aging infrastructure through investments in updating and creating new technical facilities. The NISE program has allowed the Navy Labs, Warfare and Systems Centers to revitalize and refresh the technical capabilities of the workforce through training and the support of advanced degrees and certifications. NISE programs have provided breakthrough research and been responsible for the maturation and transition of technology to the warfighter and programs of record. The NISE has encouraged cross-organizational multi-disciplinary projects that include partnerships with academia and industry. Finally, the NISE program has allowed the Navy to recruit and retain top technical talent in support of the Fleet. We want to thank you for extending the sunset clause until 2016. We would encourage you to make this a permanent authorization.

Science, Technology, Engineering and Mathematics

Our ability to support the warfighter depends on our ability to sustain a Science, Technology, Engineering, and Mathematics (STEM) workforce—with Discovery and Innovation investments supporting STEM outreach from kindergarten through post-doctoral education. One of our greatest challenges involves our concern that the number of U.S. citizen STEM graduates will not keep up with future U.S. demand or with international competition for the same talent.

Our investments seek to increase diversity and numbers of students pursuing STEM degrees. Areas of emphasis include: (1) freshman and sophomore STEM retention in college; (2) hands-on STEM programs in urban and rural middle schools; (3) teacher training in naval-relevant fields of study; and (4) mission-critical graduate student and post-doctoral support. Programs incorporate naval content, metrics to measure impact, and coordinate with other Federal STEM programs. Further, programs are selected based on potential for growth and geographic expansion, as well as ability to serve underrepresented student populations. We are in the process of developing a comprehensive metrics and evaluation plan for all STEM programs, which measures not only numbers of students and teachers, but assesses our ability to fulfill naval requirements.

Our investment in our workforce is critical but so too is our investment in our infrastructure. The Naval Infrastructure Capabilities Assessment (NICAP) initiative started in fiscal year 2010 at NAVAIR. Based on the direction of this subcommittee, DoN expanded it in fiscal year 2012 to include all RDT&E capabilities at the Warfare Centers. The expanded NICAP initiative will collect a limited amount of readily available data and is expected to be complete by the end of this fiscal year. In March of this year, we began the initial collection of information at NAVAIR, NAVSEA, and SPAWAR. Because each of the SYSCOMs use a different taxonomy to classify and manage their RDT&E capabilities, we believe that there will be some challenges in correlating the data and do not expect to be able to conduct a full comparative analysis across all of our mission areas. As such, there is a strong possibility that we will have to revisit the data in fiscal year 2014 to address areas where there are disconnects in the data provided and to implement additional tools to make the data more consistent.

The NICAP review initiative captures the "AS–IS" capability baseline to enable the integrated assessment of the RDT&E capabilities across the Department of Navy. Initial areas of focus include capability distribution, capability integration, capability alignment, capability availability and capability sustainment requirements. The NICAP provides dynamically-generated assessment views, statistical and tabular reports supporting each of the five major objective areas. These views and reports enable the comparative assessment of the current Naval RDT&E capability baseline and relevant supporting analyses for emerging infrastructure reviews.

When completed, NICAP will have captured and base lined technical information on hundreds of buildings with more than 500 different capabilities spread across 68 different geographical locations of our 14 Laboratories and Warfare Centers. The depth and the breadth of their capabilities is exceptional; in spite of some of the less than ideal conditions our scientists and engineers must perform their work.

The authority for unspecified minor construction up to $4 million, under 10 U.S.C. § 2805, continues to hold significant potential for the revitalization of Naval Laboratories and Warfare Centers. We have initiated the review and approval process for our first use of this authority at NRL. As our program begins to gain strength, we anticipate it becoming a valuable resource.

Balancing the infrastructure needs of our laboratories with the needs of the fleet and our warfighters will always be a challenge. With the current constrained budget environment, the minor construction authority granted under section 2805 becomes even more important to the revitalization of our technical infrastructure.

Improving processes to improve effectiveness

Similar to the challenge we face to maintain excellence in our technical workforce and infrastructure is the requirement to continue to push for technological innovation within the framework of affordability. The Navy's is aggressively pursuing Integration and Interoperability (I&I) with the goal of maintaining technical and operational cohesiveness across mission areas in a fiscally-constrained environment while increasing the overall capability for the warfighter.

Front end assessments based on operational evaluations that include the integration and interoperability of multiple systems ensure accuracy in determining capability gaps that will lead to better acquisition decisions to provide readiness of the Fleet. The overall objective is to produce a data informed Warfighting Capability Plan as part of the PPBS to eliminate financial waste, increase competition, and procure more relevant products. As part of this plan, the I&I initiative is not limited to just material solutions, but is evaluating probable solutions across the Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities and Policy spectrum. This approach takes a holistic viewpoint across domains and functionalities to ensure coordination and collaboration. This is in part being accomplished by modifying the Systems Engineering Test Review and Gate Review Requirements to identify problems early in the development process and thus drive for better success in the production of integrated and interoperable systems while gaining more pre-Milestone B trade space. The I&I initiative is bringing to light the organizational requirements that must be satisfied to successfully implement this approach.

The Department of Navy (DoN) acquisition leadership continues to promote the adoption of Open Systems Architecture (OSA) to support innovation, reduce the time needed to integrate improved technologies (cycle time), and lower systems' lifetime (total ownership) costs. On November 26, 2012, the Assistant Secretary of the Navy (Research, Development, and Acquisition), Mr. Sean Stackley signed out an updated Naval OSA Strategy. This strategy outlines an aggressive 4-year plan for business and technical changes. The result of executing the strategy will be affordable, open platforms (ships, airplanes, submarines, etc.) which will readily accommodate OSA-crafted modular systems (weapons, sensors, control systems, etc.). The strategy update addresses tightly coupled legacy systems and includes time and tools to evolve those to an OSA. The Naval OSA Strategy complements Better Buying Power 2.0 (BBP 2.0), recently issued by the Under Secretary of Defense (Acquisition, Technology, and Logistics), Mr. Frank Kendall. BBP 2.0 and Naval OSA continues the pursuit for greater efficiency and productivity in defense spending and are focused on total ownership costs across the lifecycle by emphasizing reuse, measurements, modularity, and reducing redundancy. Competition, using the Government's intellectual property and data rights, and breaking vendor-lock are key attributes of both Naval OSA and BBP 2.0.

With the ramp down of Urgent Operational Needs Statements (UONS) the Navy is incorporating the best of breed resources and techniques from exemplar programs such as OSD's Quick Reaction Fund (QRF) and Rapid Innovation Fund (RIF) as well as the Navy's CNO's Speed to Fleet, Tech Solutions, Technology Insertion for Program Savings (TIPS), SwampWorks, Future Naval Capability (FNC), and Rapid Technology Transition (RTT) into our core programs. Institutionalizing these techniques will result in more affordable, rapid fielding of innovative capability to the Fleet.

The defense industrial base is a critical component of the Navy's S&T strategy. As part of the Department's Better Buying Power's initiative to incentivize productivity and innovation in industry and government, the Navy is leveraging the OSD developed Defense Innovation Marketplace website (www.DefenseInnovationMarketplace.mil). The website allows for a one-stop-re-

source to keep industry and academia apprised of critical department and Navy S&T and acquisition information. These materials allow industry to better align their independent research and development (IR&D) efforts, providing Navy personnel stronger connection to projects with potential leverage for current programs and future planning. The Marketplace search functionality (now in Beta test phase) will enhance the continued communication between government and industry, as Navy acquisition community will be able to stay informed about industry's IR&D efforts. The Navy's continues to make good use of the DOD's Manufacturing Technology Program (ManTech) for industrial preparedness. As an example the Navy's ManTech portfolio contains 70 projects aimed at cost reduction efforts of the *Virginia*-class submarine with a potential for savings in of $25 million/hull.

The DoN continues to pursue partnerships with academia and industry as a critical part of our strategy to provide a cutting technological edge to the fleet. Work for Private Parties (WFPP) authorities in conjunction with Other Transaction Authority (OTA) and other technology transfer authorities provide a variety of tools that the Navy has successfully applied for affordable and effective technology development and fielding. The DoN continues to utilize its Cooperative Research and Development Agreements (CRADAs) authority. A CRADA allows partners (government and non-Federal) to save money and valuable time in achieving mutually desirable results. A non-Federal partner can provide facilities, equipment, personnel, and funding to the CRADA. DoN uses its CRADA authority to strengthen the U.S. industrial base and the transfer and acceptance of commercial off-the-shelf technology for government. DoN has entered into 3,262 CRADAs since 1989. These CRADAs directly support ongoing research projects at the DoN laboratories. There were 192 CRADAs signed in fiscal year 2012 as well as modifications to a number of existing CRADAs.

SUMMARY

With all the technological and budgetary challenges we face our goal remains the same: to ensure our sailors and marines are armed with technically superior capabilities. We can ensure this continues through disciplined processes focused on affordability, executed by a skilled workforce with technical capabilities second to none who perform state-of-the-art science and engineering in facilities that enable creativity and innovation. We have made great strides over this last year and we look forward to the continuing challenges. Thank you for your continued support and the opportunity to appear before you today.

Senator HAGAN. Thank you.

Dr. Walker.

STATEMENT OF DR. DAVID E. WALKER, DEPUTY ASSISTANT SECRETARY OF THE AIR FORCE FOR SCIENCE, TECHNOLOGY, AND ENGINEERING

Dr. WALKER. Chairman Hagan and Ranking Member Fischer, I am pleased to have the opportunity to provide testimony on the 2014 Air Force S&T program.

As our Chief of Staff, General Welsh, recently stated in his vision for airmen, our Service is fueled by innovation. The Air Force's single, fully-integrated S&T program and our outstanding scientists and engineers are truly at the forefront of this innovative spirit.

The Air Force's fiscal year 2014 budget request for S&T is approximately $2.3 billion. These investments support a robust and balanced foundation of basic and applied research and advanced technology development that will provide demonstrated transition options and support future warfighting capabilities. This year's budget reflects a strong support of S&T from our leadership in this challenging fiscal environment and is balanced across the warfighters' needs for rapid reaction solutions, mid-term technology development, and revolutionary far-term capabilities.

Despite the strong support, the Air Force S&T program is not immune to the impacts of sequestration. So far, the Air Force research laboratory has notified over 40 universities and 20 contrac-

tors regarding grants and contracts that will be terminated, delayed, or rescoped.

We are also concerned about the negative impact of sequestration on our ability to attract and retain exceptional scientists and engineers.

The total impact of the Air Force research, technology, and development activities remains unclear, but it is safe to say that many of the new and promising technologies will be delayed in their transition to the warfighter.

While there are still uncertainties with sequestration, the budget does reflect a promise of the future warfighting capabilities, enabled by technologies developed in our laboratory.

Chairman Hagan, Ranking Member Fischer, I am pleased to present the Air Force program and look forward to your questions.

[The prepared statement of Dr. Walker follows:]

PREPARED STATEMENT BY DR. DAVID E. WALKER

INTRODUCTION

Chairman Hagan, members of the subcommittee, and staff, I am pleased to have the opportunity to provide testimony on the fiscal year 2014 Air Force Science and Technology (S&T) Program. This is my first chance to address you as the Deputy assistant Secretary of the Air Force for Science, Technology and Engineering, a position I assumed in August 2012.

As the nature and sources of conflict throughout the globe have become more diverse and less predictable, our Nation continues to face a complex set of current and future security challenges many of which are outlined in Sustaining U.S. Global Leadership: Priorities for 21st Century Defense, the defense strategic guidance issued by the President in January 2012. This guidance directed a renewed focus on the Asia-Pacific region, as well as continued emphasis on the current conflicts in the Middle East. The Air Force's enduring contributions to national security as part of the joint team are more important now than ever before and we must remain agile, flexible, ready and technologically-advanced. Over the last year, the Air Force has aligned our S&T efforts to best support the Defense Strategic Guidance within current fiscal constraints. Our S&T Program supports the Air Force capabilities fundamental to the major priorities of the guidance, such as deterring and defeating aggression, projecting power in anti-access and area denial environments, operating in the space and cyberspace domains, and maintaining a safe, secure, and effective strategic deterrent. The Air Force S&T Program plays a vital role in our Nation's security by creating compelling air, space and cyberspace capabilities for precise and reliable global vigilance, reach and power.

The Chief of Staff of the Air Force, General Mark Welsh III, recently stated in his vision for Airmen that our Service is "fueled by innovation." Our single, fully integrated S&T Program is truly at the forefront of this innovative spirit and stems from several enduring tenets. First, we must prepare for an uncertain future and investigate game-changing technologies to affordably transition the art-of-the-possible into military capabilities. To support the Air Force Core Functions, we must create technology options across a wide spectrum ranging from institutionalizing irregular warfare capabilities to providing new capabilities to operate effectively in cyberspace and across all domains. We must demonstrate advanced technologies that address affordability by promoting efficiencies, enhancing the effectiveness, readiness, and availability of today's systems, and addressing life cycle costs of future systems. In keeping with our Service heritage, we must continue to foster an appreciation for the value of technology as a force-multiplier throughout the Air Force. We must maintain the requisite expertise to support the acquisition and operational communities and modernize and improve the sustainability of unique research facilities and infrastructure. Finally, we will leverage and remain vigilant over global S&T developments and emerging capabilities to avoid technological surprise and exploit art-of-the-possible technologies for our military advantage.

AIR FORCE S&T FISCAL YEAR 2014 PROGRAM

The Air Force fiscal year 2014 S&T Program investments support a robust and balanced foundation of basic research, applied research, and advanced technology

development that will provide demonstrated transition options to support future warfighting capabilities.

As a brief overview, adjustments were made within the S&T portfolio to focus investments in the most promising technologies to develop future warfighting capability. We are continuing emphasis in our propulsion portfolio by investing in the development of adaptive turbine engine technologies which will provide optimized fuel efficiency and increased performance capabilities over a wide range of flight regimes. We have emphasized research in hypersonics technologies and in electronic warfare areas to provide the capability to counter adversary anti-access and area denial approaches and effectively engage time sensitive targets. Based on the current and forecasted cyberspace capabilities, threats, vulnerabilities and consequences outlined in our recently published Cyber Vision 2025 document, we aligned and emphasized our cyber S&T investment in four areas: mission assurance, agility and resilience, optimized human-machine systems, and foundations of trust. We have also emphasized the development of technologies to address limiting capability factors of human performance in military missions including autonomy, data to decisions and human systems research. I will highlight some of these adjustments later in my testimony.

AIR FORCE S&T PROGRAM PRIORITIES

The Air Force fiscal year 2014 S&T Program supports the following overarching priorities that are detailed in our Air Force S&T Strategy document.

Priority 1: Support the Current Fight While Advancing Breakthrough S&T for Tomorrow's Dominant Warfighting Capabilities

While developing technologies to equip our forces of tomorrow is the primary objective of any S&T portfolio, our dedicated scientists and engineers have been equally motivated over the last decade to ensuring needed technologies get into the hands of our warfighters today. This valuable near-term S&T investment has saved lives in the current fights and continues to pay dividends as we transition to other focus areas in the long term. I would like to share with you a few examples of how we have supported our warfighters over the last year and how those technologies are being poised to sustain and increase military capabilities of the future.

As an example of one method, the Air Force has executed a rapid reaction process through the Air Force Research Laboratory since 2005 which has provided rapid S&T solutions to the urgent needs of Air Force Major Commands (MAJCOMs), Combatant Commands (COCOMs) and other Defense agencies. Through focused interaction with warfighters and often partnership with other Agencies, the process leverages the breadth and depth of knowledge within the laboratory and its external "innovation network" of academia and industry to deliver accelerated technology solutions in approximately 1 year or less.

This rapid reaction process has been used to develop warfighting capabilities to meet U.S. Central Command (CENTCOM) Joint Urgent Operational Needs including efforts such as Blue Devil Block 1. Blue Devil Block 1 is a persistent intelligence, surveillance, and reconnaissance (ISR) capability demonstrating the first-ever integration of wide area field-of-view and narrow field-of-view high definition day and night sensors cued by advanced signals intelligence sensors. Imagery and data are transmitted in near-real-time to an individual soldier on the ground or a Blue Devil ground station where multiple sensor data is rapidly fused for real time cueing and decisions. This new technology and lessons learned from testing in theater will improve capabilities in future systems, especially those poised for engagements where reaction timelines and aircraft access will be more challenging. In addition, the Air Force is rapidly working a variety of S&T solutions to address MAJCOM operational needs for rapid landing site survey and preparation, improved collaboration using existing infrastructure and information, and increased global command, control and communication (C3) connectivity. The Air Force has a strong record of nurturing these types of game-changing concepts using modest S&T funds along with partnerships with customers to transition technologies quickly to warfighters while leveraging the investment to inform and enhance the development of future technologies.

Even outside of the defined rapid reaction process, the Air Force S&T Program has been instrumental in quickly bringing new or enhanced operational capabilities to warfighters worldwide. For example, we are improving awareness of the global space operations through Air Force S&T support to the Joint Space Operations Center (JSPOC) at Vandenberg AFB, CA. In 2011, the Air Force Research Laboratory deployed a modern data fusion and display prototype which provides a Windows-type user interface for the 20,000 object space catalogue, modernizing from the text-based system used for the last 50 years. The prototype system provides near real-

time monitoring of all orbiting U.S., commercial and foreign spacecraft assets within a common operating picture reducing operator workload while alerting them to events in a more timely fashion. It was used in October 2012 to monitor the breakup of a Russian Breeze-M rocket body and ensure that orbiting operational space assets were safe from the newly created space debris. As this technology is transitioning to the operational Air Force through the JSPOC Mission System (JMS) program at the Space and Missile Systems Center (SMC), the Air Force Research Laboratory now provides continued upgrades for space operations on tight, 6-month spirals and accelerates transition of critical S&T products to Air Force capability.

The models of development for these technologies, as well as lessons learned, are now informing our research efforts to effectively manage and utilize the volumes of data created by the vast array of fielded sensors. While we have developed tools to fuse data from multiple sensors and sources to assist intelligence analysts in exploiting the data, most of these tools have not yet been integrated into our standard tactical intelligence processing system, the Defense Common Ground Station (DCGS). To facilitate this transition, we are building a Planning and Direction, Collection, Processing and Exploitation, Analysis and Production, and Dissemination (PCPAD)-Experimental Cell, or PCPAD–X. This will be an operationally-representative environment and innovative approach for research, development, experimentation, demonstration, and objective evaluation to facilitate transition of technologies for mission driven PCPAD. It will provide a realistic "analyst-in-the-loop" environment which does not exist today, complete with validated subjective and objective performance metrics, for testing potential analysis capability improvements. This environment will allow us to run existing and new analytical tools through the PCPAD–X to more quickly and affordably identify "best of breed" tools for transition.

The Air Force S&T Program is also supporting the current F–22 Raptor fleet while planning to enhance warfighter effectiveness in next generation platforms. The Air Force Research Laboratory supported the Safety Investigation Board, Scientific Advisory Board, the Root Cause Corrective Action analysis, and is a major participant in the Air Combat Command-led F–22 Life Support Systems Task Force. To address life support issues, laboratory personnel provided expertise on oxygen systems, toxicology, aerospace medicine/physiology, epidemiology, and bio-environmental engineering. Scientists and engineers from the laboratory identified on-board oxygen generating system (OBOGS) limitations and recommended parameters for OBOGS challenge testing, resulting in a new Department of Defense (DOD) Air Quality Standard. They also developed and flew a helmet-mounted pulse oximeter for use on the F–22 in 90 days and then transitioned the design for fleet-wide operational fielding. To address multiple Air Force demand signals and future concerns due to the increasingly complex and capable fighter aircraft in development, the Air Force has begun reconstituting aerospace physiology/toxicology core competencies at the Air Force Research Laboratory. Using research and technology developed in response to the F–22 issues, this program will provide evidence-based understanding of pilot physiologic response to new air platforms, characterize physiologic performance for new flight envelopes, understand physiologic impacts due to toxic exposure, and understand unexplained cognitive dysfunction that can occur in some pilots.

Priority 2: Execute a Balanced, Integrated S&T Program that is Responsive to Air Force Service Core Functions

Our Nation depends on the Air Force to counter a broad range of threats that could limit our ability to project global reach, global power, and global vigilance. Even as we emphasize focus on the Asia-Pacific region, we are aware that we cannot predict with certainty the time, place, or nature of the next contingency where airpower will be needed. The Air Force's technological advantage is threatened by the worldwide proliferation of nuclear weapons and advanced technologies, including integrated air defenses, long-range ballistic missiles, and advanced air combat capabilities. In addition, advances in adversarial capabilities in space control and cyber warfare may limit Air Force operations in air, space, and cyberspace. Some of these technologies are attained with relatively minimal cost; greatly reducing the barriers to entry that have historically limited the reach and power of non-state actors, organized militias, and radical extremists. Today's strategic environment indicates the military need for flexibility and versatility which requires a shift to inherently agile, deployable, and networked technologies and systems—including legacy systems—designed to accomplish a multitude of missions.

Through prioritization and planning, the Air Force fiscal year 2014 S&T Program provides the technical edge to affordably meet these threats during this time of fiscal constraint. Since high-payoff technologies are needed to sustain our air, space, and cyberspace superiority in an increasingly competitive environment, we are

smartly investing in a broad portfolio of technologies aligned with the Defense Strategic Guidance that are balanced across the warfighter's need for near-term, rapid-reaction solutions; mid-term technology development; and revolutionary, far-term capabilities.

At the Service level, the Air Force has matured its S&T planning processes a great deal over the last year by improving the alignment between S&T efforts and capability gaps outlined in Air Force Core Function Master Plans (CFMPs). Our robust research program pushes the technological state of the art across a range of areas for potential military application as well as being responsive to technology needs expressed by the operational community. The established S&T planning governance process ensures S&T investments are well understood, structured for success, and poised for transition when completed. This process is the backbone of Air Force S&T contributions to the larger DOD priorities and strategies and has provided us opportunities to lead the Department's research and strategic planning efforts in some areas including cyber, autonomy, electronic warfare and manufacturing technology. These planning efforts also support the Department's Better Buying Power 2.0 initiatives to achieve greater efficiencies in acquisition, including developing stronger partnerships with the requirements community, using the technology development phase for true risk reduction and incentivizing productivity and innovation in industry.

To illustrate how the Air Force S&T Program is supporting our national security by providing the necessary speed, range, flexibility, precision, persistence, and lethality across all domains (air, space, and cyber), I would like to highlight some of our efforts in the areas we are leading for the Department as well as across our portfolio of contributions:

Speed can contribute to survivability of Air Force systems and allow us to engage time sensitive targets even in the anti-access/area-denial environments we increasingly expect to encounter in the future. Starting in early fiscal year 2011, the Air Force S&T community—in collaboration with industry—developed roadmaps for high speed technology options for Air Force missions in anti-access/area-denial environments. The Air Force focused its S&T investments in two key areas: technology for survivable, time-critical strike in the near term and a far-term penetrating regional Intelligence, Surveillance, and Reconnaissance (ISR) aircraft.

Our survivable, time critical strike technology effort includes research and advanced technology development efforts that support the maturation to Technology Readiness Level 6 (TRL 6) of Mach 5.0 plus cruise missile technology. Detailed roadmaps have been developed, which include advanced guidance technology, selectable effects ordnance, airframe technology, and expendable cruise propulsion. The technologies requiring early flight testing are included in a demonstration effort that will begin later in fiscal year 2013 called the High Speed Strike Weapon (HSSW).

HSSW is an integrated technology demonstration that was proposed by the same Air Force and industry team who developed the overall Air Force S&T plan/roadmaps in the high speed area. Key to HSSW's tactical relevance is its compatibility with Air Force 5th generation platforms to include geometric and weight limits for internal B–2 Spirit bomber carriage and external F–35 Lightening II fighter carriage. It will also include a tactically compliant engine start capability and launch from a relevant altitude. The flight demonstration will be the first tactically-relevant demonstration of Mach 5.0 plus airbreathing missile technology. This effort addresses many of those items necessary to realize a missile in this speed regime including: modeling and simulation; ramjet/scramjet propulsion; high temperature materials; guidance, navigation, and control; seekers and their required apertures; warhead and subsystems; thermal protection and management; manufacturing technology; and compact energetic booster technologies. The Air Force is actively pursuing a partnership with the Defense Advanced Research Projects Agency (DARPA) on this demonstration to leverage their recent experience in hypersonic technologies that are relevant to HSSW and other hypersonic systems.

Analysis of challenges in the future security environment has made clear that our advanced munitions technology like the HSSW and other existing or advanced munitions will need to operate when the Global Positioning System (GPS) signal is either degraded or perhaps even denied entirely. As such, we have focused on pursuing a number of munitions guidance technologies that will allow us to continue to operate much as we have become accustomed today. These include technologies that expand upon our current anti-jam GPS navigation capabilities and novel technical approaches to navigation such as optic field flow techniques and multi-sensor fusion. These techniques allow the Air Force to harvest information regarding these systems as they traverse through their flight environment and infer the necessary navigation information.

The importance of dominance in the cyberspace domain cannot be overstated as it is a foundation for global vigilance, reach and power. Cyberspace is a domain in which, from which and through which all military missions are performed and is becoming increasingly contested or denied. The Air Force has placed great emphasis on S&T efforts to overcome threats and provide systems and methods that are affordable and resilient. The Chief Scientist of the Information Directorate of the Air Force Research Laboratory located in Rome, NY ("Rome Lab"), has been charged to chair the collaborative, Joint cyber S&T road-mapping efforts for DOD based on the Laboratory's history of exceptional cutting-edge cyber research.

Recognizing that sound strategies are the foundation for wise investments, the Air Force Office of the Chief Scientist partnered with operators and technologists from across the Air Force, government, industry, academia, National Laboratories, and Federally Funded Research and Development Centers to develop Cyber Vision 2025 last year. Cyber Vision 2025 describes the Air Force vision and blueprint for cyber S&T spanning cyberspace, air, space, command and control, intelligence, and mission support. It provides a long-range vision for cyberspace to identify and analyze current and forecasted capabilities, threats, vulnerabilities and consequences across core Air Force missions in order to identify key S&T gaps and opportunities. The Air Force's cyber S&T investments are aligned to the four themes identified in Cyber Vision 2025: Mission Assurance, Agility and Resilience, Optimized Human-Machine Systems, and Foundations of Trust. Cyber Vision 2025 and our associated cyber S&T strategy guides the research conducted at the Air Force Research Laboratory ensuring the relevance and efficiency of our technology development for Air Force and national security users.

Air Force S&T efforts in Mission Assurance seek to ensure survivability and freedom of action in contested and denied environments through enhanced cyber situational awareness for air, space, and cyber commanders. Research efforts in automating network and mission mapping are working to provide warfighters with the ability to detect and operate through cyber attacks with threat warning, integrated intelligence, and real-time forensics/attribution. We are also focused on developing technologies to achieve cross-domain integrated effects and determine cross-domain measures of effectiveness (MOEs), including cyber battle damage assessment.

Our research in Agility and Survivability is focused on minimizing future system risk by reducing attack surfaces, segregating critical mission systems, and developing methods to contain attacks. Air Force S&T efforts are creating dynamic, randomizable, reconfigurable architectures capable of autonomously detecting compromises, repairing and recovering from damage, and evading threats in real-time. The Air Force is also enhancing cyber resiliency through an effective mix of redundancy, diversity, and fractionation (i.e., distributed functionality).

We are also working to maximize the human and machine potential through the measurement of physiological, perceptual, and cognitive states to enable personnel selection, customized training, and user-, mission-, and environment-tailored augmented cognition. Air Force S&T efforts are developing high performance visualization and analytic tools to enhance situational awareness, accelerate threat discovery, and empower task performance.

The Air Force is developing secure foundations of computing including trusted fabrication technologies, anti-tamper technologies, and supply chain assurance, as well as effective mixes of government, commercial off the shelf, and open source software to provide operator trust in systems (e.g., sensors, communications, navigation, command and control). Research into formal verification and validation of complex, large scale, interdependent systems as well as vulnerability analysis, automated reverse engineering, and real-time forensics tools will improve security at all levels of technology implementation. Further, efforts exploring high speed encryption, quantum communication and, eventually, quantum encryption will further increase the confidentiality and integrity of supporting infrastructure.

The security atmosphere of today, and that which we can visualize in the future, requires our military aircraft to operate in highly contested environments. Manipulation of the electromagnetic spectrum—called electronic warfare—can help us negate the integrated air defenses of our adversaries. Over the years, we have developed stand-off, on-board, and off-board capabilities to protect fighter and bomber aircraft; however, our adversaries continue to evolve their capabilities at the same time. As the lead for the DOD Electronic Warfare Priority Steering Committee, the Air Force has been charged to facilitate road-mapping efforts for research in new technologies and techniques to be effective against the new threats involving ways to defeat new sensors operating in new frequencies, more elaborate detection methods, and greater computational and networking capabilities of adversaries. The new technologies and techniques being created feed into Air Force and Navy upgrades to a range of military aircraft including fighters, bombers, support and decoy air-

craft. For example, the Eagle Passive/Active Warning Survivability System (EPAWSS) effort for the F–15 Eagle is leveraging the Air Force Research Laboratory Sensors Directorate work in advanced digital receiver technology as one key architecture option.

Research in our Directed Energy portfolio has also shown promise in the development of capabilities to defeat our adversary's electronic systems on the ground. In October 2012, the Air Force successfully flight tested a system called the Counter Electronics High Powered Microwave Advanced Missile Project (CHAMP). During the flight test, the CHAMP cruise missile navigated a pre-programmed flight plan and emitted bursts of high-powered microwaves at targets containing a wide range of representative electronic equipment, effectively delivering a functional disable of the systems without harmful effect on people or structures in and around the target area. This successful test culminated the CHAMP Joint Capabilities Technology Demonstration and moved the Air Force closer to providing combatant commanders with a non-kinetic counter electronics capability as a complement to lethal measures, increasing mission options for the warfighter.

The Defense Strategic Guidance pivot to emphasis on the Asia-Pacific region means missions with expanded duration, intermittent communication disruptions, high rate of changing situations, and a larger array of asset capability. These realities require research in both human systems and performance to better enable warfighters to enhance military capabilities as well as autonomous systems which can extend human reach by providing potentially unlimited persistent capabilities without degradation due to fatigue or lack of attention. Since they are investment priorities, the Department has established cross-Service steering groups for both human systems and autonomy to roadmap and coordinate research efforts in these areas. The Air Force is leading the autonomy steering group and is an active member of the human systems group.

The Air Force envisions that the greater use of autonomous systems will enable United States forces to operate well within the "decision loops" of our adversaries. Such increases in machine autonomy will require humans and automated systems to work as a team, with some level of decisionmaking delegated to the machine counterpart. We seek to enable the right balance of human and machine capability to meet Air Force challenges in the future and are focused on growing autonomous system capability, integrated with the human capacity to perform in a high-tempo, complex decision environment, and to optimize humans working together with machines, both effectively and efficiently.

To achieve this, the Air Force is developing technologies to enable Airmen and machines to work together, with each understanding mission context, sharing understanding and situation awareness, and adapting to the needs/capabilities of the other. The keys to maximizing this human-machine interaction are: instilling confidence and trust among the team members; understanding of each member's tasks, intentions, capabilities and progress; and ensuring effective and timely communication. This must all be provided within a flexible architecture for autonomy, facilitating different levels of authority, control and collaboration. Current research is focused on understanding human cognition and applying these concepts to machine learning. For example, we are developing efficient interfaces for an operator to supervise multiple MQ–9 Reaper platforms and tools for ISR analysts to better identify and track targets of interest. We are also conducting human systems research in the areas of decisionmaking, training, bioeffects, and human-centered ISR. We have increased our emphasis in training research with the objective of providing live, virtual, and constructive rehearsal capabilities to increase affordability by reducing training time by 30 percent, increasing training effectiveness by 15 percent, and creating common methods for cross-mission application. As a result of this research, the Air Force will be more efficient and effective while tailoring training and rehearsal to the point-of-need to keep pace with rapidly evolving and complex threats.

Today there is little cross-platform interaction or coordination without a human engaging in the interaction. Therefore, the Air Force is developing cooperation technologies that will allow machines to autonomously synchronize activity and information to take our military capabilities beyond human limitations. Systems that coordinate location, status, mission intent, intelligence and surveillance data can provide redundancy, increased coverage, decreased costs and/or increased capability. The Air Force's research efforts are focused on developing control software to enable multiple, small unmanned air systems to coordinate mission tasking with other air systems or with ground sensors and also on developing munition sensors and guidance systems that will increase operator trust, validation, and flexibility while capitalizing on the growing ability of munitions to autonomously search a region of interest, provide additional situational awareness, plan optimum flight paths, de-con-

flict trajectories, optimize weapon-to-target orientation, and cooperate to achieve optimum effects.

The Air Force's mission to fly, fight and win in air, space and cyberspace, requires a tremendous amount of energy. In fact, our Service uses approximately 2.5 billion gallons of aviation fuel per year and is the largest fuel consumer in the Federal Government. As such, we are pursuing research into technologies to reduce energy demand for both legacy and future aircraft.

For example, in conjunction with Air Mobility Command, the Air Force Research Laboratory is conducting promising research to reduce drag on C–130 Hercules aircraft, one of the primary fuel consumers in our legacy fleet. This low-cost aft-body flow control research, consisting of microvanes and finlets, will reduce the flow separation around the cargo ramp and the horizontal junction with the fuselage. Flight testing to date has shown that these devices can save 3 to 5 percent of total aircraft drag during normal flight conditions. The Air Force has developed and funded a two-phase flight test process to optimize the design of the devices to provide the maximum fuel savings possible without having detrimental effects on airdrop operations, basic loadability, handling qualities and structural dynamics. Phase I (early operational assessment) testing was successfully completed at Yuma Proving Ground in November 2012. Phase II (fuel flow, handling qualities and structural dynamics) testing is on schedule for late spring of this year. This modest research investment could save approximately $130,000 per year, per aircraft and the resulting production versions are installable at the field level, meaning minimal downtime for the warfighter and depot level maintenance savings.

For the longer term reduction in energy demand, the Air Force is investing in the development of adaptive turbine engine technologies which have the potential to reduce fuel consumption by 25 percent in comparison to current turbine engines by enabling optimized performance over a wide range of flight conditions. These technologies also increase capability in anti-access/area denial environments by increasing range by 25 to 30 percent or increasing time-on-station by 33 to 40 percent.

The Air Force initiated investment in adaptive engine technology through the Adaptive Versatile Engine Technology (ADVENT) program. This research is being leveraged by our current Adaptive Engine Technology Development (AETD) program. AETD will mature ADVENT and additional technologies, including inlet and exhaust systems, to TRL 6 to reduce risk for follow-on activities and facilitate integration into multiple platforms to realize operational benefits. Investments in these efforts helps us reduce energy demand, bridge the "valley of death" between S&T and potential acquisition programs, and help maintain the U.S. industrial technological edge and lead in turbine engines.

The Air Force is also the lead for the Department in the development and demonstration of technology solutions that decrease manufacturing risk and increase weapon system affordability for aerospace propulsion, structures and ISR systems. Simply stated, a more capable and lean warfighting force requires a much more efficient and responsive manufacturing and industrial base than we currently have today. The Air Force Manufacturing Technology program explores strategic issues and opportunities in manufacturing and industrial readiness including moving manufacturing considerations to bear earlier in the design cycle to reduce acquisition cost and risk; enabling a seamless life-cycle value stream management through a cradle-to-cradle digital design thread to improve process control, optimization, and agility; integrating the industrial base enterprise to predict, identify, and react to supply chain issues; and creating the factory of the future with flexible, robust tooling and machine cells for limited part runs.

For example, the Air Force Manufacturing Technologies program conducts Manufacturing Readiness Assessments on new technology, components, processes, and subsystems in order to define the current level of manufacturing maturity and identify associated risk. A number of major DOD weapon system suppliers and Original Equipment Manufacturers (OEMs) have integrated manufacturing readiness levels into their gated technology transition processes to help decide when a technology is mature enough to use in a product design. As a result, prime contractors and other OEMs are making better decisions about which technologies to include in product designs resulting in reduced cost, schedule and performance risk. This past year, the advanced manufacturing propulsion initiative continued activities to reduce the weight and cost of turbine engines through advanced manufacturing of light weight castings and ceramic composites. The advanced next generation radar and coatings affordability projects continue to reduce technology cost and manufacturing risk to systems such as the F–22 and F–35 aircraft.

The Air Force S&T Program is also supporting the President's Materials Genome Initiative (MGI) aimed at doubling the speed and reducing the cost of discovering, developing and deploying new advanced materials. The MGI is engaging all stake-

holders in the materials development community which spans academic institutions, small businesses, large industrial enterprises, professional societies, and government. Our supporting effort is called Integrated Computational Materials Science and Engineering (ICMSE) and its objective is to develop quantitative and predictive techniques for the field of materials science and engineering (MSE) to bring similar benefits to MSE that have been realized from Finite Element Analysis or Computational Fluid Dynamics in aircraft design.

ICMSE requires new, science-based capabilities in order to create fresh approaches for the design of materials. Coupled with materials design is the need to develop a robust, two-way conduit between materials design, manufacturing, and component design. The Air Force, Johns Hopkins University, and the University of Illinois have teamed to form a center-of-excellence (COE) to innovate new solutions for pervasive ICMSE issues, including physics-based multi-scale modeling and uncertainty quantification. While the COE explores basic science underpinnings for ICMSE, nearer-term approaches to integrate the continuum spanning materials design and vehicle design are being explored in concert with vehicle/component designers, manufacturers, materials suppliers, and materials developers. Two Air Force-relevant engineering problems (high-temperature metals and composites) establish the scope on which to develop, test and demonstrate approaches for ICMSE.

Research in our space portfolio also addresses how to accomplish the Air Force mission with resiliency and affordability. For example, we are seeking to provide added protection to our satellites by increasing the robustness and resiliency of the most susceptible spacecraft components which will provide affordable options for a more-defendable space capability. The Air Force collaborates with NASA on research in space communications to extend the frequency trade space and create options for future space communication satellites. We are also continuing to mature technology for next-generation GPS user equipment with anti-jam capability for contested theater operations, including the transitioning of the cold atom technology from basic to applied research which offers great promise for operating in GPS-denied environments. In the space situational awareness area, the Air Force S&T enterprise operates two 3.5 meter class telescopes and several smaller ones that, as well as performing research, are used to support satellite owners in determining the health/status of their satellites using high resolution optical images instead of the traditional radar.

To reduce the cost of space access, the Air Force is researching ways to improve Evolved Expendable Launch Vehicle capability through increased use of multiple payloads. Air Force S&T maintains a long-term investment in pervasive spacecraft technologies, such as more efficient space solar cells that can reduce solar array mass by 40 percent.

Space experiments, such as the current Advanced Responsive Tactically Effective Military Imaging Spectrometer payload on TacSat-3 and the Communications/Navigation Outage Forecasting System, are a critical tool used to develop and prove new technologies and phenomenologies. Future experimental satellites include the Automated Navigation and Guidance Experiment for Local Space, which will research local space surveillance, and the Demonstration and Science Experiment, which will research approaches to counter a space nuclear detonation.

Development of revolutionary, far-term capabilities begins with scientific discovery and the building of foundational knowledge with our investment in basic research. Based on visions of the future established by Air Force leadership, Air Force scientists and engineers identify, nurture and harvest the best basic research to transform leading-edge scientific discoveries into new technologies with substantial military potential. These technologies transform the art-of-the-possible into near-state-of-the-art and offer new and better ways for the acquisition community to address far-term warfighter needs. While it can be more of a challenge to quantify long-term basic research, with the scientists and engineers at the Air Force Office of Scientific Research within the Air Force Research Laboratory actively engaged in worldwide technical communities, the Air Force has leveraged significant investments made by other defense and Federal agencies, as well as non-defense and international laboratories, in its on-going efforts to advance basic science.

For example, an Air Force basic research funded project in quantum storage at the University of Maryland has demonstrated for first time that multiple images can be stored and retrieved at different times based on interaction between light and matter. In this atomic memory, light signals can now be stored as patterns in a room-temperature vapor of atoms that are tailored to absorb and later re-emit messages on demand. Quantum storage capabilities will exploit quantum effects for computing and communications are vital to increasing the speed, capacity and security of our networks and computer systems of the future. The researchers are con-

tinuing to understand entangled quantum memories for use in securing long distance transmission of secure information through optical fiber systems.

While most of our investments in the Air Force S&T Program focus on developing and advancing technologies for the future, S&T also has an important role to play in providing technology options to increase the availability and decrease the life cycle costs of our legacy platforms now. Many of the Air Force's current aircraft were manufactured decades ago and are experiencing age-related issues, such as cracking and corrosion, especially after nearly 20 years of unabated use. Our S&T efforts to address sustainment issues not only pay dividends now but also provide options when designing and building future systems. We are focusing our sustainment efforts in three areas: inserting new technologies in legacy systems to better and more affordably sustain the fleet, developing technology-based approaches to improving fleet health management and introducing new design approaches for future systems and components.

For example, over the last year our research had yielded results in addressing critical cracking issues with the C–5 Galaxy aircraft floor bulkhead end fittings. The cracks, caused by stress corrosion, led to increased maintenance costs and reduced the amount of cargo that could be carried on the aircraft. Using a new, more stress corrosion-resistant aluminum alloy, researchers developed a new die forging process by which all of the 92 fitting shapes required for the C–5 bulkhead could be produced using only two separate forging dies. The new technology, which has now been transitioned to the Warner Robins Air Logistics Center, provides many benefits including a 25 percent overall cost savings, an 80 percent reduction in fabrication time and a 60 percent increase in service life of the fittings.

The Air Force is also a key member of the multi-Service Advanced Technology Demonstration (ATD) addressing propulsion sustainment for current and future aircraft. The team is working to provide hot section component durability which is a significant driver of maintenance costs. This effort is focused on advanced turbine cooling and aerodynamics technologies that reduce weight and allow engines to run hotter at the same material temperature thereby producing more thrust. These types of technologies are aimed at benefitting turbine engine programs across DOD including current programs, such as the F–35, as well as future Air Force programs, such as the Long-Range Strike bomber.

Priority 3: Retain and Shape the Critical Competencies Needed to Address the Full Range of S&T Product and Support Capabilities

The U.S. Air Force is the most technologically advanced air force in the world – and we intend to keep it that way. Technology is part of every mission we perform, and innovative and technically-savvy Airmen are our most important asset. The Air Force ensures we continue to have war-winning technology by careful and proactive management of our Science, Technology, Engineering, and Mathematics (STEM) workforce.

Through implementation of Bright Horizons, the Air Force STEM Workforce Strategic Roadmap, and the Air Force Systems Engineering Strategic Plan, we continue to develop and retain a workforce with the skill sets necessary to create compelling air, space and cyberspace capabilities for precise and reliable global vigilance, reach and power. The Air Force is progressively developing a highly qualified engineering workforce with the engineering competencies required to support the acquisition of warfighting systems. We continue to be appreciative of the Laboratory Demonstration authority and are investigating opportunities to expand the program to our entire STEM workforce.

The Air Force conducted an in-depth review of our STEM requirements and is revamping our accession and recruiting processes to help career field managers obtain the right skill sets. Over last 8 years in the Science, Mathematics, and Research for Transformation (SMART) Scholarship Program, the Air Force averaged 60 scholarships per year to scientists and engineers; after payback commitment, we retained 88 percent of scholars in Air Force jobs. Through an innovative Section 219 (of the Duncan Hunter National Defense Authorization Act of 2009) workforce initiative, the Information Assurance Internship funds 10 to 20 college juniors and seniors in STEM disciplines to study the science of information assurance and information warfare on Air Force problems. For instance, last year's interns, who averaged a 3.8 grade point average, developed a mathematical model for the MQ–9 Reaper remotely piloted vehicle in a contested cyber environment. The Air Force utilizes this initiative to attract and offer employment to the best and brightest cyber students. An objective of our workforce strategy is to improve the pool of diverse candidates available to enter our STEM workforce. We also continue to have a vibrant relationship with Historically Black Colleges and Universities and Minority Serving Institutions (HBCU/MI), who conduct research projects, improve infrastructure, and intern

with the Air Force Research Laboratory in support of the Air Force mission. The Air Force uses essential tools, such as the SMART Program and the Information Assurance Internship, to renew and grow the required skill sets critical for Air Force mission success. The Air Force remains dedicated to improving our force management processes to attract, recruit and retain STEM talent.

Priority 4: Ensure the Air Force S&T Program Addresses the Highest Priority Capability Needs of the Air Force

As discussed earlier, the Air Force S&T planning and governance process ensures the Air Force S&T program addresses the highest priority capability needs of our Service. The Air Force Core Function Master Plans (CFMPs) play a critical role in this process by identifying S&T needs as they relate to capability gaps, requirements, and potential materiel solutions.

Among other things, this process has allowed us to create and execute Air Force Flagship Capability Concepts (FCCs). Key factors in commissioning this type of an Air Force-level technology demonstration effort include having a well-defined scope and specific objectives desired by a MAJCOM. The technologies are matured by the Air Force Research Laboratory with the intent to transition to the acquisition community for eventual deployment to an end user. These FCCs are sponsored by the using command and are vetted through the S&T Governance Structure and Air Force Requirements Oversight Council to ensure they align with Air Force strategic priorities. Currently, the Air Force is working on three FCCs: the High Velocity Penetrating Weapon (HVPW), Precision Airdrop (PAD), and Selective Cyber Operations Technology Integration (SCOTI).

The HVPW FCC was established to demonstrate critical technologies to reduce the technical risk for a new generation of penetrating weapons to defeat difficult, hard targets. This FCC is maturing technologies that can be applied to the hard target munitions acquisition including guidance and control, terminal seeker, fuze, energetic materials and warhead case design. This effort is developing improved penetration capability of hard, deep targets containing high strength concrete with up to 2,500 feet per second (boosted velocity) impact in a GPS-degraded environment. This technology will demonstrate penetration capability of a 5,000 pound-class gravity weapon with a 2,000 pound weapon thus increasing the loadout for bombers and fighters. Testing in 2013 has demonstrated warhead survivability and several sled tests are scheduled for the first quarter of fiscal year 2014.

The PAD FCC was commissioned in 2011 in response to a request from the Commander of Air Mobility Command for technologies to improve airdrop accuracy and effectiveness while minimizing risk to our aircrews. The Air Force Research Laboratory, Aeronautical Systems Center, and Air Mobility Command members established a working group to explore all aspects of the airdrop missions from re-supplying our warfighters in the field to providing humanitarian aid to people in need across the globe. To date, PAD FCC efforts have focused on: early systems engineering analysis to determine major error sources, data collection, flying with crews, wind profiling, designing high density pallet rollers, and designing modeling and simulation (M&S) activities. We expect demonstrations to begin in late calendar year 2013.

The SCOTI FCC is executing smoothly toward providing cyber technologies capable of affecting multiple nodes for the purposes of achieving a military objective. SCOTI directly meets the needs of a major capability area in the Air Force Cyberspace Superiority Core Function Master Plan and provides a non-kinetic alternative to an adversary's operations. The standardized delivery platform being developed is scheduled to be complete in fiscal year 2013 and will serve as a baseline for current and future integrated cyber tools. The SCOTI stakeholders signed the finalized Technology Transition Plan in March, clearly identifying how SCOTI is expected to transition to the warfighters for operational use. SCOTI is on track to be delivered to the Air Force Life Cycle Management Center in fiscal year 2013 for integration with additional mission software, and Initial Operational Capability can be achieved as early as fiscal year 2016. In the past year, the stakeholders also completed SCOTI's Test Master Plan, and warfighters from the 166th Air National Guard conducted system-level tests on two development spirals of SCOTI technology with positive results. SCOTI is on track to meet all eight of its technical performance measures and provide the desired capability to the warfighter.

To ensure these FCCs and other advanced technology development efforts are postured for successful transitions to warfighting capability, the Air Force is continuing deliberate efforts to better align S&T planning, technology transition planning, and development planning. The linkages between these planning activities are critical to initiating acquisition programs with more mature technologies and credible cost estimates, and we are mandating this linkage in new Air Force policy.

The Air Force is also engaging small businesses through the Rapid Innovation Fund (RIF) to rapidly insert innovative technologies into acquisition programs that meet critical national security needs. In the first year (fiscal year 2011), the Air Force solicited innovative technologies in five broad thrust areas for this program: (1) Rapid Fielding to Support Overseas Contingency Operations; (2) Cyberspace Superiority and Mission Assurance; (3) Improved System Sustainment; (4) Power Generation and Energy for Platforms; and (5) Joint Urgent Operational Needs with an Air Force interest. After receiving 729 white paper proposals from vendors in 44 States, the Air Force awarded 46 contracts, all of which went to small businesses.

We have experienced a similar reaction from industry to our fiscal year 2012 RIF broad agency announcement which solicited innovative technologies from more than 40 thrust areas submitted by the Air Force's Program Executive Offices (PEOs). The more than 700 white paper proposals received will be evaluated by a team from across the Air Force. We expect to make award notifications for the fiscal year 2012 RIF program in the spring of this year.

Overall, the Rapid Innovation Fund presents an opportunity to transition innovative technology into Service programs. The Rapid Innovation Fund provides a vehicle for businesses (especially small businesses) to easily submit their innovative technologies where they feel it will best meet military needs. The Air Force benefits by having the ability to evaluate proposed innovative technologies against critical needs and selecting the most compelling for contract award.

Through the Small Business Innovation Research (SBIR)/Small Business Technology Transfer Program, the Air Force continues to garner the creative, innovative, and entrepreneurial spirit of small businesses to solve many technological problems. In that regard, we are pleased that the SBIR program was reauthorized through 2017 and many of its provisions expanded or made permanent. As we implement the provisions of the reauthorization, we intend to collaborate with other Federal agencies, where practical, to ensure that our processes are streamlined, efficient, and that small businesses continue to be a major driver of high-technology innovation and economic growth in the United States.

CONCLUSION

Our emphasis areas reflect our re-focused S&T portfolio given budgetary challenges and the Defense Strategic Guidance. I believe these areas also reflect the promise of future warfighting capability enabled by the technologies that will be developed with Air Force S&T Program investment. We recognize that these challenges will not disappear tomorrow, and that is why we have improved our processes to make better investment decisions and to capitalize on these investments to efficiently deliver capability to our warfighters. We continue to institutionalize these initiatives in our policies and procedures across the Air Force. The S&T portfolio we present to you today, after all, is the genesis of our warfighting capability of tomorrow. Our Airmen and our Nation are depending on it!

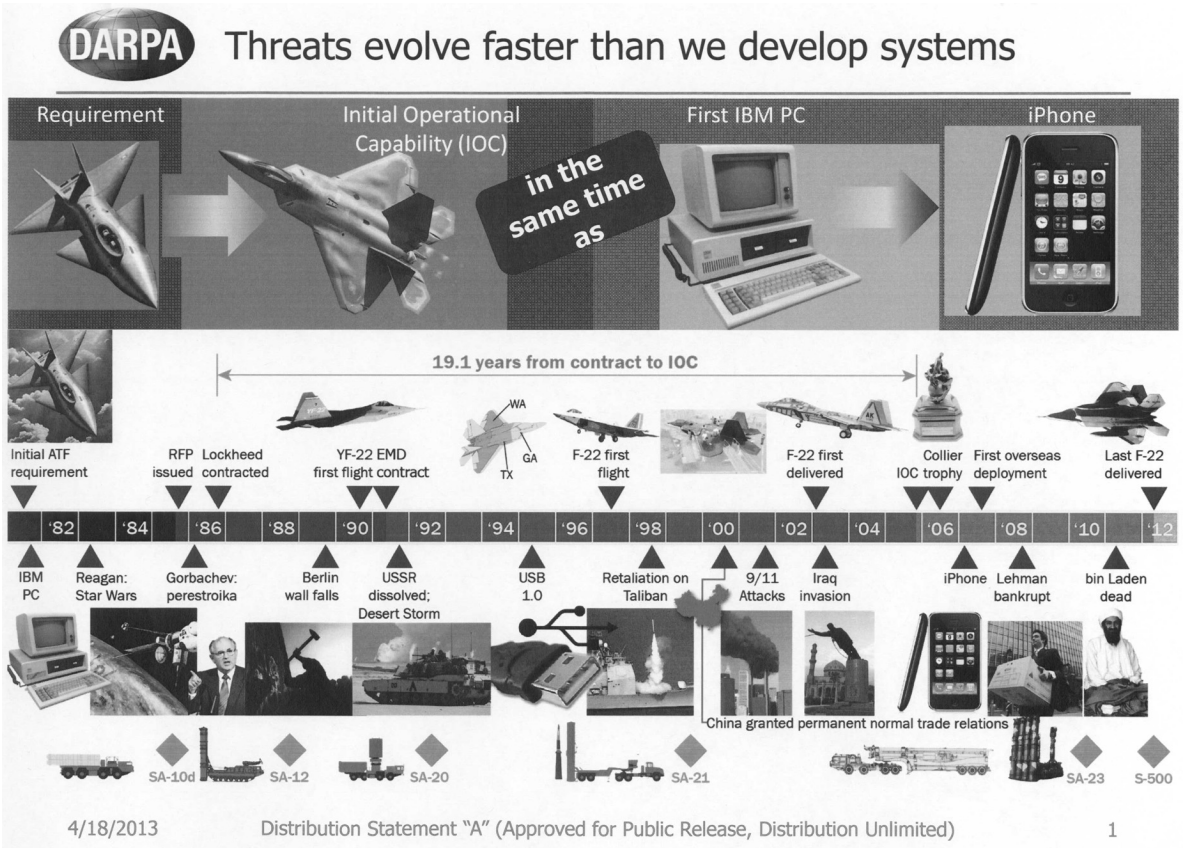
Chairman Hagan, thank you again for the opportunity to testify today and thank you for your continuing support of the Air Force S&T Program.

Senator HAGAN. I thank all of you very much.

I know sequestration really has had a negative impact on all of these disciplines, and it is something, I am sure, we will be talking about more. It really does concern me greatly especially, Dr. Walker, your last comment about the ability to retain the current scientists and as engineers that are currently working throughout the disciplines of civilians in DOD.

So let us look at my handouts, the two charts.

[The information referred to follows:]


DARPA
Threats evolve faster than we develop systems
Requirement
Initial Operational Capability (IOC)
in the same time as
First IBM PC
iPhone
19.1 years from contract to IOC
Initial ATF requirement
RFP issued
Lockheed contracted
YF-22 EMD first flight contract
F-22 first flight
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IBM PC
Reagan: Star Wars
Gorbachev: perestroika
Berlin wall falls
USSR dissolved; Desert Storm
USB 1.0
Retaliation on Taliban
9/11 Attacks
Iraq invasion
iPhone
Lehman bankrupt
bin Laden dead
China granted permanent normal trade relations
SA-10d
SA-12
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4/18/2013
Distribution Statement "A" (Approved for Public Release, Distribution Unlimited)
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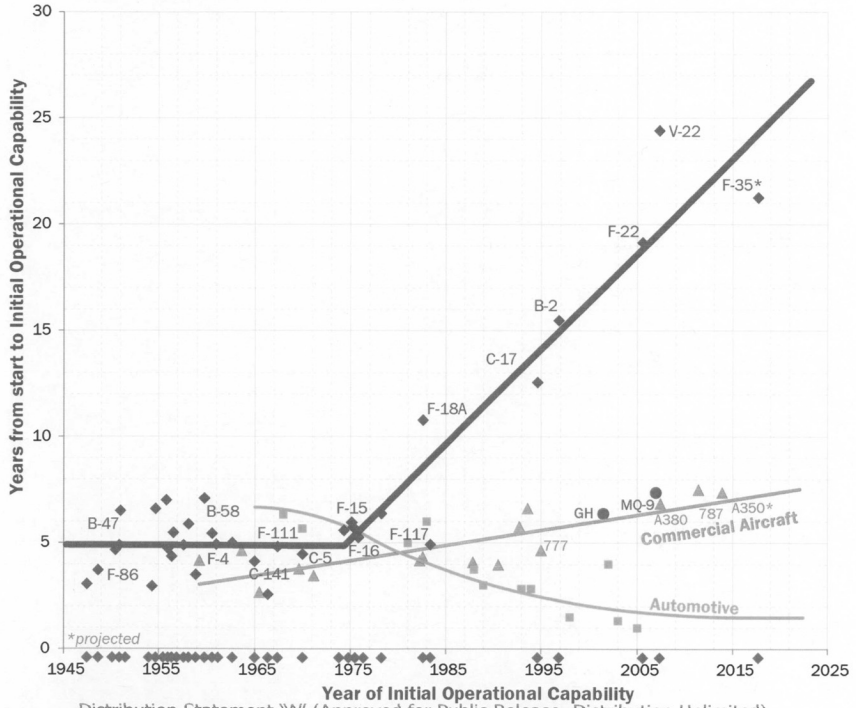
Clear time trend in defense new start aircraft developments



Sources: D. Patt
DARPA/TTO 2012 study

Senator HAGAN. These two charts were taken from a DARPA presentation on the defense aircraft industry last year. The first one titled: "Threats evolve faster than we develop systems," depicts an example of how these threats evolve much faster than the time it takes for us to actually develop these systems, such as the F–22 fighter. During the time from the initial requirement of the advanced technical fighter in the early 1980s to the first F–22 delivered in 2003, this chart depicts how the world had significantly changed, both in terms of threat and in terms of technologies. Especially today when we are talking about the budget, the sequestration, the impact of the time alone certainly would impact the budgeting consequences and issues.

Then the second chart titled: "Clear time trend in defense new start aircraft developments," shows the time that it has taken DOD to develop the aircraft from an historical perspective. The chart shows the time it took from the start of an aircraft program to the time it first flew in an operational capability over the years, once again from the 1940s until now. Note that this time from program start to first operational flight has significantly increased.

The interesting thing, I think, too on this chart is it shows a comparison of development time for commercial aircraft and then the commercial automotive sector. As you can see, they are diametrically opposed to what it is from the military.

Now, I know that we have to heavily caveat these charts because these increasing delays over time are due to a host of issues, including budget pressures and I know the acquisition system inefficiencies, change orders, et cetera. So I am not implying that this is solely a S&T issue.

But to me, these charts really do stress a key concern that is relevant to the panel today. With the rapid pace of global technological development, we no longer have the luxury of thinking about an idea, developing it, waiting a decade or more to field these weapons systems.

So I would like each of you to address the following. What is the DOD S&T enterprise doing to ensure that DOD is able to take advantage of the latest technological developments and make sure that they are infused in a timely and affordable manner into current and future programs of record? Mr. Shaffer, if you would like to start, and we can just go down the panel.

Mr. SHAFFER. Certainly. I would like to highlight two things that DOD is doing in S&T.

The first is we are trying to put more developmental prototyping in our 6–3 program. The reason we are trying to do that is it is much cheaper to test out concepts and capabilities in S&T than it is in full-up acquisition. In fact, if you look at your chart here, the period where we were flat with very short delivery—and there are certainly a number of factors—happens to coincide when DOD and NASA were in full scale with their X-plane prototype period. We had the X–1, X–2, through the X–15. None of those were designed to be fully operational systems, but we actually prototyped parts of those systems very early. Mr. Kendall has asked myself and asked also DARPA to take a look at doing additional prototyping in these spaces to drive down the cost and time.

The second thing that we are doing, and this is really with DARPA and the Services—is we are gathering up all of our folks in our laboratories who are working in the area of system design. We have a program—they are terrible names—Engineering Resilient Systems, and it is led by Dr. Jeff Holland, who is the technical director at the Army Corps of Engineering Lab in Vicksburg, a strange place for it, but he has a very big effort.

We are looking at how do we do more system design in computers so you can do a much broader range of trades in computers rather than bending metal and also design in things like open systems to the maximum extent possible. So as we have long developments, we can do very easy modular changes to the design and we can do that in a computer instead of on an assembly line.

I highlight those two areas. If those two pan out, we will dramatically reduce the cost of new systems, the time to develop, and also importantly, we will stock the cupboard for when the acquisition budget grows again so we will have capabilities to keep our forces safe.

Thank you.

Senator HAGAN. Dr. Prabhakar?

Dr. PRABHAKAR. Let me start by just putting my comments in the context that you started with, which is to recognize that there are so many factors behind any of these phenomena.

From the technology end, what we are really seeking are some technical approaches and demonstrations that might serve to poke that system and show that there are some different ways of doing business in the hope that that will help trigger a change in the overall process because that is really what it is going to take.

I want to break the question into two pieces. First, is the platforms that we build, and the aircraft that these charts focus on are a great example of that, the major vehicle systems that we build. Then second, the capabilities that go on them, be it electronic warfare or communications or sensing whatever job we are trying to do. I think that there are important innovations in both of those.

On the platform side, a key theme that I think many of us see is that as these acquisition processes stretch out, that just creates more time for requirements to continue to change and for more and more iterations which creates a situation where it is literally decades and the whole thing does not really close. So one of the key concepts that is behind several of our programs is: are there approaches that will collapse that time so that we can much more quickly get to a capability and not have this long period of time during which we are continuing to move the requirements around. We are working towards that in some of our manufacturing programs.

As well, when we do X-plane or other X-platform projects, these are not acquisition programs, but at the R&D stage, we are really looking at innovative business models and have had some very good success in doing demonstrations that are much faster and for far fewer dollars than anyone thinks is possible simply by building the right incentive structures, by having very specific objectives that do not change, some of those kinds of practices. So that is platforms.

I think I am actually much more encouraged by what is going to be possible as we change the systems that go onto our platforms, and electronic warfare is a particularly good example. Today when we build a new electronic warfare system, we are building something that is monolithic and it is very complex. When our adversary changes what part of the electromagnetic spectrum they are working then we have to start all over and redesign the whole thing. We are building a new architecture that will allow us to be extremely agile so that when the threat changes, we can adapt in real time without having to ditch that whole thing and go through this next laborious acquisition process.

So those are a couple of the ideas.

The big point in my mind is that for so many years affordability has been the conversation you have after you do the innovation. A challenge that we are really putting out to the leading edge technical community is to say where are the innovations that will completely flip the cost equation, not just make incremental changes because I think that can be powerful, but it has not been historically the question that we have been asking.

Senator HAGAN. Thank you.

Ms. Miller?

Ms. MILLER. Thank you.

As Mr. Shaffer said, prototyping is a big activity that we are doing to try to better inform our requirements, requirements that often are reaching a little bit too far and take us a long time to achieve. What we have been doing within the Army is working with our requirements community and our S&T community to better inform those requirements. The prototypes help to set us up for good capacity in that regard because we can show what is technically achievable and we can drive down risk.

In addition, within the Army, I mentioned our strategic modernization strategy we are developing. This is a 35-year look out into the future. What it does is it allows us to align the programs of record and their lifecycles against where they need technology insertion and where we need to have new platforms, perhaps, to replace them. That helps to, again, inform requirements and helps to baseline our S&T investments so that we can do this insertion. It is actually aligning us so that our technology is there when it is needed, not too early, not too late, and we will, again, try to shorten up our——

Senator HAGAN. It seems 35 years is an awfully long time from a planning perspective in today's highly technical architecture and field.

Ms. MILLER. Yes, ma'am. I wish I could say that we did not have platforms that lasted that long, but ma'am, we do and we do need to have technical upgrades as we go along. That is why it is important to understand the lifecycle of the platforms and when we can have technical insertions.

I would also argue, and it has been mentioned, that we do not really know what threat will be there in 30 or 35 years, but the fact is, if you stretch something out that far, you certainly know the world is going to be different. It breaks people from saying I am just going to do what I am doing now for a little bit longer.

They have to think differently. It has opened some new trains of thought with people that pretty much have been closed thinking.

Senator HAGAN. That is why I like, Dr. Prabhakar, your comment about when the threat changes, that you can quickly adapt.

Ms. MILLER. Absolutely.

The other aspect that we are doing is looking to the international community and what technologies they can bring in. We talked about open architectures and systems engineering, and we are looking at the international community to see what they can bring in and augment the Army's capabilities. I am certain that is true across all of the Services and DARPA because we are never going to say that we are the smartest people here. Everybody has good ideas. We need to know how to use them.

Senator HAGAN. I am already running close. We are going to have 10-minute sessions. So let us move on. Thank you, Ms. Miller.

Ms. Lacey?

Ms. LACEY. So I will agree with everyone, all the comments that have been made so far.

I will cite two specific examples. One is a rapid prototyping that you probably heard a lot about in the last couple of weeks, our high-energy laser demo on an operational platform in the Gulf. So that should give us some context, some learning, some understanding, so we can make sure that as we move into the development phase, that we have provided a capability that the warfighter can actually use.

Senator HAGAN. What does this laser do?

Ms. LACEY. It is a high energy laser and it will shoot down air targets or fast attack craft targets close in on the surface. So we are going to be doing a demonstration of that coming up in 2014. I am very excited about it.

The comment I would like to make about open architecture—we too are moving in that direction. It is not so much driven by S&T, but it is certainly enabled by it. But the real key is to open up what you already have. As Ms. Miller pointed out, we are going to have systems for 35 years. In our case, we have aircraft carriers for 50 years. If we do not open those systems up now, we are not going to be able to take advantage of these S&T breakthroughs as they happen. So we in the Navy are spending a lot of time doing that as we move forward.

Senator HAGAN. Thank you.

Dr. Walker?

Dr. WALKER. The Air Force is in lockstep with the other Services and the Acting Assistant Secretary of Defense for R&E as well.

A couple of things I did want to address, though, is I really like your slide because I am doing a study right now that our chief scientist, Dr. Mark Maybury, is running on Global Horizons, which is really looking at the future of S&T and how we take that to improve the Air Force of the future. I am leading a team that is doing mission support which is really how do we improve the acquisition system so that we can bring in new technology faster. This slide is my number one trend slide that I am using.

It was interesting. When I started looking into this, we really have driven ourselves into a long acquisition process. We are not following the trends of other agencies, and we want to take advan-

tage of that. We started asking questions. The automobile industry, which is actually coming down—they actually are using four times the number of lines of code in a modern automobile than we use in the F–35. Yet, they are able to do it faster. One of the reasons is because they learned to use loosely coupled software, use loosely coupled systems as opposed to our approach which has been highly integrated systems.

So when you start looking at how do we have an evolvable system, which is really addressing that issue of requirements—requirements change over time. From the time you define what you want to have to the time you actually have it fielded and, much worse, 60 years later when you are still using it like we are using some of our aircraft, you have to be able to evolve and you need to design the system so it can evolve along the way. Having loosely coupled, where possible, allows you to do that and is much more flexible.

Taking advantage of the digital design and building a digital thread, taking advantage of advanced manufacturing capabilities—these are all ideas of how we can improve our ability to get from technology ideas into warfighting systems.

Senator HAGAN. Thank you.

Senator Fischer?

Senator FISCHER. Thank you, Madam Chairman.

I would just like to follow up with you on the line of discussion that Chairman Hagan was discussing. When we talk about collapsing time and looking at the changes that are occurring and looking out 35 years and adapting and evolving, is that happening now? Is that happening now or is that your plan and goal for the future? Is that the direction you want to head or are you headed in that direction now? If you are headed there now, have you had any successes that you could share with us where you have been more able to adapt in a quicker manner?

Dr. PRABHAKAR. I will kick off.

Let me just shift to a different realm than aircraft. An example I really love of adaptability—your big question was are we doing this yet. I would say we have been trying for a while and it is slow progress, but there are some examples where we are making progress.

One that I really like has to do with the situation our soldiers on the ground were facing in Afghanistan. The intelligence that is collected from the battlefield all gets pulled up, but the soldiers on patrol from 1 day to the next do not really have the kind of immediate, fresh information from their colleagues as they go every day when they go out on patrol. So one of the projects that we did, we would hear sometimes from these young soldiers that they had left a civilian world where they could walk around with maps on their iPhones and know where they are and post text notes to their friends. Now they are in Afghanistan and all of that is gone when they really could have used it.

It turns out those things are much harder to provide in a battlefield environment. Security is a real concern. The connectivity does not really exist. You need secure and physically hardened devices. So there was a whole host of challenges.

In some work that we did where we did get real devices in the hands of soldiers, we were able to give them handhelds where they would have these kinds of applications that looked like the applications that they used in the civilian world, and they used these applications in just very practical ways. So soldiers would go out, they are going out on patrol, they are recording the local observations of what is this farmer doing in this field or what is the scuttlebutt that they are picking up as they are talking to people. That is immediately fed to their colleagues and to the guy that is going out on patrol the next day.

Senator FISCHER. So it is not just going up. It is really——

Dr. PRABHAKAR. It is laterally. Exactly.

The thing that I think is really great about this, because I love what we are doing for the soldiers today, but really the exciting thing to me is we are introducing this element of adaptability because the applications that they use one day tell them what the applications are that they need the next day. The development team that we have sitting next to them then will spin up that application, and a few days later, they are able to have a new capability that matches the particular thing that they are trying to track or a particular way that our adversary might have adapted on the other side.

So it is just one little example, but when you see the power of that kind of ability to react, I think it does tell you where we could go.

Senator FISCHER. Good. That is good to hear.

I would like to talk about sequestration and the effect that that is going to have on the groups that you are representing. Sequestration could reduce the Federal R&D spending by $57.5 billion, or 8.4 percent, through 2017. Spending on defense R&D could be cut by $33.5 billion, or 9.1 percent. That is going to bring the spending levels for defense down to the 2002 level.

Do you have any specific S&T sequestration funding numbers for fiscal year 2013 and a breakdown of how it is going to impact your programs?

Mr. SHAFFER. Yes, ma'am, and we can provide that to you. I mean, I do not have it in my pocket.

[The information referred to follows:]

The fiscal year 2013 sequester amount for science and technology (S&T) program is $1.035 billion less than the President's budget request of $11.861 billion as shown in the below chart, this was roughly a 9 percent reduction.

[In billions of dollars]

	President's Budget Request 2013	Sequestration Cuts to President's Budget Request 2013	President's Budget Request 2014 (Fiscal Year 2013 CY $)
Basic Research (6.1)	2.117	-0.176	2.164 (2.128)
Applied Research (6.2)	4.478	-0.403	4.627 (4.549)
Advanced Technology Development (6.3)	5.266	-0.456	5.192 (5.105)
Department of Defense Science and Technology	11.861	-1.035	11.984 (11.782)

Impact to S&T programs were varied and resulted in outright program reductions and delays. In many cases, work in S&T is sequential, the work planned for fiscal year 2013 will be deferred to fiscal year 2014—and reduces the work planned in fiscal year 2014 by that same $1 billion. Some of the reduction will be seen at our government labs, but other impacts will be seen in government and universities. For

example, we expect the total investment in universities to decline by about $250 million. This will reduce our overall number of grants going out to universities by somewhere between 500 and 1,000 grants. Since manpower in our S&T laboratories is funded with Applied Research, we were left with the choice of reduce program content or people. A reduction of $400 million within Applied Research equates to more than 1,500 scientists and engineers; we forestalled these layoffs in fiscal year 2013 but not for much longer. Sequestration cuts have also impacted the S&T laboratories to hire scientists and engineers into critical positions. Within the Assistant Secretary of Defense for Research and Engineering portfolio, there will be no new technology demonstrations in fiscal year 2013. These specific examples are only an illustration of $1.035 billion cut to the DOD S&T program. The impact of these cuts will not only affect today's S&T program but will have lasting effects in the future.

Mr. SHAFFER. The basic rule of thumb, 9 percent to every program element and project across DOD in RDT&E. So you can take whatever was appropriated in fiscal year 2013, subtract 9 percent from that. That will cause terminations in some cases. It will cause certainly slowdowns to all of our programs.

The place that it will hurt, I think, the worst is the reduction in the number of grants and new awards. We heard Ms. Lacey say that the future naval capability new starts are cut in half. I will start no new technology demonstrations for fiscal year 2013. We will reduce our overall number of grants going out to universities by somewhere between 500 and 1,000. That does not sound like much, but when we in the United States are struggling to have enough scientists and engineers to work on national security problems, I do not know which of those 500 or 1,000 grants might give me a very good scientist or engineer to come work in my laboratory. But if we reduce the pool, we reduce the future. Those are the impacts of sequestration.

We are all in the business of an uncertain future. We were talking before this hearing started. We have some members in uniform who say, just fund the basic research projects that are going to pan out. We wish we were that good. You have to fund a number of things and then some of them will bubble up. By reducing the pool, we are going to reduce the future.

I want to point out one thing that we are talking about within DOD. In previous periods, the last two big budget contractions for DOD, Secretary Perry was involved in both of those. He made a strategic choice to maintain investment in R&D because we are cheaper and we provide options. We are working through that argument. I do not know if that is going to hold for this time or not. But in the past, there has been a strategic choice in our Government to maintain the future.

Senator FISCHER. Would it be more helpful if you had flexibility to decide where you were going to make those cuts and make them more targeted?

Mr. SHAFFER. Yes, absolutely.

Senator FISCHER. Would it be less harmful to the programs that you deal with?

Mr. SHAFFER. Absolutely.

Senator FISCHER. So you could make wiser decisions if we would give you the flexibility to let you make those decisions within your department?

Mr. SHAFFER. Absolutely.

Senator FISCHER. Did anyone wish to add anything on that point?

I happen to believe that we need to make sure that the funding and the programs need to be focused on our warfighters. So while sequestration may impact each of your organizations, the impact I am concerned with is, what is going to happen with regard to those warfighters and the warfighting capabilities? So what specific aspects and impacts will those cuts due to sequestration have on our warfighters and those specific capabilities?

Ms. MILLER. I guess I will start.

Senator FISCHER. If it remains like it is now and you do not have the options to make decisions yourself.

Ms. MILLER. As you have already heard, sequestration is not only impacting our programs. In some cases, we will terminate some of our S&T efforts, efforts that may well have produced capability for the warfighter. We are also certainly going to constitute a delay in what we can deliver. It will be an impact to getting things through the acquisition system and improving what we have.

Certainly in the Army, we have a lot of systems that are coming back out of the war, becoming programs of record, becoming part of our main set of equipment, and it would be up to the S&T community to make sure that those pieces of equipment then are operational and can be upgraded and perform much more capably and affordably. So we will look to try to invest our resources, what we have of them, to make sure that we have platforms that are affordable and that do not cost as much money and perhaps not make as many new designs based on the limitation in the funding, certainly tied to what the warfighter wants.

Senator FISCHER. The budget that you were looking at, the five of you, was the budget introduced by the President. Is that correct?

Ms. MILLER. Yes, ma'am.

Senator FISCHER. So that did not account for sequestration. If we are going to account for sequestration, have you dug into that even deeper to find out what will need to be done? Have you looked at that at all?

Mr. SHAFFER. Are you asking have we gone through a prioritization to begin to understand how we would deal with it in 2014 if sequestration actually hits? Yes, ma'am, we are doing it.

Senator FISCHER. Well, it has hit.

Mr. SHAFFER. It has hit.

Senator FISCHER. It has hit, but the budget that was introduced did not have that accounted for in it.

Mr. SHAFFER. That is absolutely correct.

Of course, we are looking at how we would prioritize. Yes, ma'am.

Senator FISCHER. The rest of you, would you answer please?

Dr. PRABHAKAR. Absolutely.

Just for context, in our work, which is projects-driven, we do not have standing laboratories for the work that we do at DARPA. We are in a constant process of prioritizing in the normal course of business. So when something like sequestration hit in fiscal year 2013, of course, we started with our lowest priority programs that were struggling already or, for whatever reason, there was a problem. But when the cut is as substantial as it was in fiscal year 2013, it does cut into the things that we very much would have wanted to do. So the consequences there included delays to impor-

tant programs. Plan X, which is our cyber offense program that is just beginning, is an example. Delays on transition.

One of the very interesting things we are seeing is the secondary effects because we do so much of our work with our partners in the Services, be it contracting or when things are more mature when we are going to field tests or going to test ranges. We are finding that all of those schedules now are delayed and pushed out.

So the net effect from a 1-year hit in fiscal year 2013 tends to be a series of delays. It is not the end of the world for our mission in the long-term. It is just very corrosive and extremely demoralizing to our program managers that we worked very hard to get in the door.

One time, you can absorb that. My concern, about if this continues, is then it does start getting at our fundamental ability to create, in our case, these big leap-ahead technologies. So, instead of just a few months of delay, if we end up starting to have to cut into the actual work and drop things on the ground, that is where I think the bigger impacts loom, which would be much more dangerous.

Senator FISCHER. Just maybe a quick answer from the other three. I am way over my time.

Ms. MILLER. Yes, ma'am. We are looking at prioritization and what we will no longer be doing and aligning it with our programs of record and what the warfighter needs.

Ms. LACEY. We are doing that as well in the Navy and the Marine Corps.

Dr. WALKER. We are also in the Air Force. The alignment to a given program element and the hits on certain programs will cause us to have to either realign programs within the Air Force or to delay in some of the key programs, particularly the bigger demonstrations that are closer to warfighter needs.

Senator FISCHER. Thank you. I am glad to hear that you are all being very realistic about the current law that we are under and the budget situation that we face. Thank you.

Senator HAGAN. Thank you.

Dr. Prabhakar, you just mentioned the Plan X, and I wanted to address that. The President and the leadership of DOD from the Secretary on down have emphasized the importance of cyber to our Nation's security and prosperity and continue to increase investment in this area despite the declining overall budgets.

DOD has turned to DARPA for substantial investment in this leap-ahead technology. DARPA's role is especially critical as a highly credible source of alternative approaches to operating in cyberspace from those developed by the National Security Agency and the cryptologic services of the Army and the Navy and the Air Force. It is very concerning to see that DARPA has levied a 43 percent cut on this flagship cyber program called Plan X in allocating sequester reductions in the portfolio.

Why is this flagship cyber program being cut so significantly, and what are the broader implications because of this 43 percent cut?

Dr. PRABHAKAR. That is a great example of the unfortunate impact of sequestration because when we are done making the cuts that we can live with, then we get to the things that we are not very happy about having to live with.

The Plan X program that you cited is one component in an overall set of activities that we are doing in cyber. I do not want you to take away a notion that it is a 43 percent cut to our entire cyber portfolio. The Plan X program is just ramping up, and that was one of the reasons that we felt that was the right place to take that portion of the cut within that program element relative to the other hundreds of contracts that were underway in that program element. We had to choose among our children there.

But just to paint a little bit broader picture, you are absolutely right. Cyber is something about which there is enormous concern in terms of cybersecurity. DARPA's role very much as in other fields is not operational. There are many other parts of DOD and the Intelligence Community as well that are focused on the operational mission. I think they are putting enormous effort into keeping up with this growing threat.

What we are trying to do is come up with the technology ideas that change the trajectory because right now the threat keeps growing and all we really have as solutions is to hire people, of which there are not enough because they need special training, and every time there is an attack, we patch and then we hope. That is essentially all we can do.

We have two themes and Plan X is one of them. The other piece is about cyber defense, first of all, which is trying to build—and I think we actually have some phenomenal programs that will build—the technical ability to create a more fundamental defense, ways to assess legacy systems and assure that they are secure and also then to build new systems, for example, embedded systems that might go into our advanced military platforms, build them in a way that is much more inherently secure. So I think with those technologies, we can get to a place where we get beyond just throwing people at it and get to a much more automated future for security.

Then for cyber offense, back to the Plan X story, the dream here is right now our warfighters are engaged in, and they know how to fight a kinetic fight. Electronic warfare is a fully integrated part of that. But cyber sits off on the side. It is not a tool that someone engaged in that kinetic activity can really bring to bear in an active situation. It is because cyber offense tools are things that are exquisite pieces of software that you write. You really do not know for sure what they are going to take out when you launch them. Once you launch them, you do not really know what other collateral damage they have. They really are not weapons in the conventional warfighting sense. Building those capabilities is what the research program in Plan X will do, and that is, obviously, why we are very excited about pushing it forward as aggressively as we can.

Senator HAGAN. So do you feel comfortable, or somewhat comfortable, with the funding for the defensive part of cybersecurity issues?

Dr. PRABHAKAR. I think we have been able to size that at a place where we are making the investments that have the greatest promise for big impacts. So, yes, I am comfortable with that.

Senator HAGAN. We certainly need to go back and look at Plan X too, in my estimation, going forward, for sure.

Mr. Shaffer, last month Mr. Frank Kendall, the Under Secretary of Defense for Acquisition and Technology and Logistics, was quoted at a conference saying that he is considering a strategy of funding R&D projects despite the ongoing budget pressures. His objective is to fund R&D projects to keep the leading edge of the industrial base working on advanced technologies when budget pressures are significantly impacting major acquisition programs.

Two thoughts, two questions. What are you doing to implement this strategy?

Then also, in the President's budget, you have more than doubled the funding for the emerging capabilities technology budget line from $25 million to $62 million and have also created a new applied research for the advancement of S&T priorities with $45 million. Can you describe what this funding is for and how will it address the key issues of increasing responsiveness to develop and to deploy new technologies and affordability?

Mr. SHAFFER. Yes, ma'am. There are actually two threads in there, so let me start with the first one.

We have touched on this a little bit already. Mr. Kendall is asking us to take a look at prototyping, late development prototyping demonstrations for a couple of reasons. One is to develop new capabilities. A second is to keep design teams employed when we are going through periods where we are not buying them out of equipment. So when you look at advanced technology, the real secret sauce are those really smart design team engineers who will go ahead and create the new trades and possibilities. So we will do some prototyping in some of those areas, I believe, to make sure that we keep the national intellectual capital viable for when we need the next set of systems.

So that is where Mr. Kendall is looking. He is looking, through DARPA, at something called the next generation air dominance initiative to really look at what are the pieces for the next generation fighter or network set of fighters that we need to keep in place so that when we actually go to the next generation aircraft, hopefully it will not take 30 years to develop and that we will have the right smart people in place.

The second question you asked, and by the way, and I have in my own lines in the Office of the Secretary of Defense increased the funding for prototyping in the emerging capabilities technology demonstration program. They will be doing prototyping in things like very advanced electronic warfare systems and things like some cyber capabilities. It is where we have to address new and emerging capabilities.

The $45 million for the applied technology program actually is not a new start, new set of money. I took five or six of my old programs and collapsed those into a single program element to be able to fund good ideas competitively across DOD in the cross-cutting areas that everybody has S&T programs in: communications, cyber, electronic warfare, materials, those types of things that all of my partners here are funding at some level. We want to have a program to put connective tissue to make their programs better. All of that $45 million will be executed through the Services. So it is a new way of thinking about how are we going to get more bang

for the buck by funding internally competitively proposed projects in those certain cross-cutting areas.

Senator HAGAN. Thank you.

Ms. Miller, Ms. Lacey, and Dr. Walker, in the fiscal year 2014 budget request, DOD has more or less preserved its top line funding for S&T. In part, this is due to increases in basic and applied research at the expense of advanced technology development. While increased basic research is important, there are concerns over decreases in more applied research funding and for activities that can help transition technologies across what has classically been labeled the valley of death, the gap between the labs and then the military users.

Do you feel the balance between basic research, applied research, and advanced technology development is right, and what is your assessment of our funding for technology development across the valley of death? Ms. Miller?

Ms. MILLER. I will start, ma'am.

I think that the balance needs to be looked at. I think that we have done a good job in pushing resources down into basic research and now applied research, but it has caused an even earlier valley of death.

Senator HAGAN. If you have any examples, I love examples.

Ms. MILLER. I would tell you in this budget development, we ended up decreasing our budget activity 3, advanced tech development resources, on the order of $140 million pushed into other 6–2 areas, and we took our tech maturity, so I should start with the Army established a 6–4 line for their S&T activities to help do prototyping and to cross the valley of death. Those resources have also been reprogrammed into the 6–1 and 6–2 at this time to make sure that we could meet compliance and have those next generation capabilities.

But at this point, we need to start being cognizant of the ability to take those good ideas that are developed in earlier research veins and be able to transition them through. We will be looking to try to get a better balance from here on out.

Ms. LACEY. I too agree that the balance needs to be relooked. We have seen that valley of death or the interpretation of it being a valley of death widen over the years. In reality, what we have done is we have moved things that historically had been in procurement accounts back into the R&D accounts. We have a lot of pressure on our 6–4 accounts that we currently have today, which is the traditional transition zone, and 94 percent of our money in what is BA–4 through BA–7 in the Navy is tied to programs of record. We have very little that is focused on that transition area, and that is something we need to look at very, very carefully DOD-wide. By preserving the 6–1 and 6–2, a very noble thing to do, at the expense of the 6–3 and 6–4, we are actually widening that valley.

Dr. WALKER. In the 2014 budget submission, we were actually able to increase our 6–3 at a greater rate than our 6–1 and 6–2 trying to reverse a trend that we have had over the last few years. 6–1 and 6–2 tended to dominate the S&T budget. But we have the same problem as the Navy. Our 6–4 program, our BA–4 is primarily tied to programs of record, and we miss that opportunity to move beyond the laboratory and into a demonstration and develop-

ment program getting ready prior to a program of record being in place. That is an area that we think we need to improve as well.

Senator HAGAN. Thank you.

Senator Fischer?

Senator FISCHER. Thank you, Madam Chairman.

I would like to talk about furloughs for civilian personnel that you may have. We know that it causes loss of productivity. I think it will harm our military readiness at a time when we are facing, I think, more serious threats than many other times in history for this country. Furloughs will have a significant impact on employees' families and also on our States' economies.

While DOD has decided to reduce the number of furlough days, I remain deeply concerned about the impact of those furloughs on the things that I mentioned. Your scientists, your engineers, your program managers play a critical role in maintaining our superiority on the battlefield because of the research that you are doing. I have heard that the Navy and the Marine Corps have funds available to avoid furloughs, but DOD, the Army, and the Air Force will have furloughs for their civilian employees.

I have three questions for you. What is the current status of furloughs in each of your organizations? What would be the impact if you had to furlough some or all of your civilian employees? Would any of your civilian employees be exempt?

Mr. SHAFFER. Ma'am, the actual implementation of furloughs is still an ongoing process, but right now it looks like across the board in DOD, the policy will be 14 days for civilian personnel taken over the last 14 weeks of the year.

The reason that this step is being taken is because of the inability to move money between accounts from one to the other. We, DOD, are in what I consider to be a very terrible place. We either fund the ongoing war efforts for our deployed forces or we furlough. So there are other ways at the margin to get there, but at the end of the day, we are so underfunded in our operations and maintenance (O&M) accounts right now in DOD that we have to take the drastic steps. None of us particularly like furloughs. I have talked to Dr. Prabhakar and she actually has a different problem. She hires people for 4 years and they want to come in and do things. It is going to be very upsetting that they are not going to be allowed to do things.

I also want to point out that while we have a furlough of 14 days, it is not just the 14 days that is going to impact us. One of our Services, in fact, all of our Services, are dramatically under-represented in contracting officers. In addition to furloughs, people who are currently being paid overtime will no longer be paid overtime. They will not be allowed to work overtime. So it is not going to be just the cut of 14 days, it is going to be a reduction in many cases of people who are putting in 50- to 60-hour weeks and getting paid for it being cut to 32 hours. So that will impact getting money out the door and on contract.

There is a whole host of second-order impacts due to sequestration, but those are all going to hurt everybody on this panel and it is going to hurt our young people. We are breaking faith with our young people, many of whom, at least in this area, are living

very close to the margin and have mortgages to make and that type of thing.

So this is a very serious step. None of us like it. We understand why DOD is taking it. It is where we are, ma'am.

Dr. PRABHAKAR. I think Mr. Shaffer said it all.

I will just add you asked about exemptions. In my organization, the furlough applies to civilian Government employees and we will be taking that across the board, including myself and my deputy. We have one civilian Government employee who is in Afghanistan for some of the field test work that we are doing, and we are sorting out that situation. But that would be the only exemption, if there is one.

Ms. MILLER. Pretty much what Mr. Shaffer said applies to all the rest of us.

Ms. LACEY. In terms of exemptions, we are looking at health and safety issues as potentials at the moment.

Dr. WALKER. For us in the S&T workforce, it will be no exemptions, just for the health and safety issues, but right now, we do not have any of those.

Senator FISCHER. Once again, I would ask you with regard to flexibility, if we would be able to give you flexibility to make decisions within your own programs, would that help with the furlough situation?

Mr. SHAFFER. Ma'am, I think that this is all tied into flexibility with O&M accounts and because of the way we have to spend money, funding the war efforts forward. We are rapidly running out of time because O&M for the Army and the Navy are 1-year money. So even if we start to get flexibility late in the summer, it is going to be very hard to move money from one account to O&M and then get that spent. So we have a double whammy going on. It is the color of money but it is also the time of the year and whether or not we would actually be able to expend it.

Mr. Hale, a wonderful guy, I am surprised he has any hair left because every time I go by him, he is pulling more of it out. It is a very difficult management problem.

Senator FISCHER. So are you saying with regard to the furloughs, the flexibility really would not help at this point at all?

Mr. SHAFFER. It is beyond our ability to deal with. This is really a larger issue coming from Dr. Carter, the comptroller, and Secretary Hagel and how they would be able to manage the war effort. That is what is driving everything. Internally, I do not think that it would help much.

Senator FISCHER. Thank you.

I would like to move on to infrastructure, if I could, with modernization and duplication. The lab enterprise includes 62 organizations spread across 22 States, with a total workforce of about 60,000 employees, more than half of whom are degreed scientists and engineers. That infrastructure supports this enterprise like the rest of DOD and continues to age with no military construction (MILCON) funding in sight to modernize your facilities.

The NDAA for Fiscal Year 2013 Senate Report required DOD, the Air Force, and the Navy to conduct a survey of its laboratory infrastructure and brief the congressional defense committees on the results of their surveys no later than March 1, 2013. I believe

the Army has provided their survey, but we are waiting to receive some surveys from DOD and the Navy.

What is the overall status of your facilities and how does that status and the state of your infrastructure affect your mission?

Ms. LACEY. Ma'am, where we are in the Navy, we have actually baselined the buildings that we have, and we can quote a number. But that is not very informative when it comes to understanding what can you do with that building. You have to couple it with the equipment that is in it and the people so that we can understand the real capability. That is where we are right now is trying to make sure we understand that.

Senator FISCHER. Are you completing your survey now? Will we be receiving a briefing on that?

Ms. LACEY. We can give you a briefing, but I want to be careful here. We have completed our survey on the facilities themselves, the building piece. What we really are interested in is the capability piece, and we are only about halfway through that. So we expect that it will be sometime early next fiscal year before we have our first look at that.

But do we have old buildings? Yes. The fact of the matter is that our scientists and engineers are very dedicated folks that do amazing work despite the buildings that some of them have to operate in. Would I like it to be better? Absolutely. But we are trying to determine right now what we really need to invest in. Making every building very nice may not be the right answer for the Navy for the long term.

Senator FISCHER. Dr. Walker?

Dr. WALKER. I believe we have turned in our survey. The Air Force survey of the building facilities is like Ms. Lacey was saying. About 90 percent of our buildings are actually in fairly good shape. We put a lot of effort into this, both in good support from Air Force MILCON, MILCON inserts that we have gotten over the time, and the recent base realignment and closure allowed us to modernize a number of our areas.

We have also taken advantage of section 219 to really work the lab piece of it and start to modernize the interior of the buildings because a lot of our buildings were built in the 1960s and 1970s and they do not need to be replaced. They just need to be modernized in place. We have also modernized older buildings with the recent MILCON at Wright-Patterson where we took a shell of a building and completely rebuilt the interior of it to make a world-class, modern power lab for the Aerospace Systems Directorate. So we have taken advantage of this. The Air Force has been very good to us.

We realize in this day and age of where we are in the fiscal environment, we are probably not going to get MILCON for a time in the Air Force, but we have actually taken advantage and using section 219 are able to keep the labs to the par that we would like to have them on.

Senator FISCHER. Have you looked at what it would cost if you truly were going to modernize for not your wants but your needs for your mission?

Dr. WALKER. We have taken the surveys of that. I do not have that number off the top of my head, but it is not a small number.

Senator FISCHER. Thank you.

Senator HAGAN. Just so the panel knows, we are going to stop the meeting right before 4 p.m.

I have a question on the Rapid Innovation Program. Three years ago, Congress established the Rapid Innovation Program to help fund the rapid transition of innovative technologies largely from the small business community to the warfighter. This was an environment where rapid fielding of technologies was driving a significant level of the effort on the S&T community. As we draw down our combat operations overseas, the demand for rapid fielding may diminish.

What are your views on the Rapid Innovation Program? From my understanding, this program is not included in the fiscal year 2014 budget request. Is this program not useful now to DOD in the current environment? Mr. Shaffer?

Mr. SHAFFER. Yes, ma'am. The reason it is not in the 2014 budget request is that we have just gone through and we have done the first year's worth of awards. We are waiting to see how this program pans out and the types of products that come out of it before we put in a budget request. It is not clear that we would get new money.

There would be other ways we could do this. As you mentioned, most of the Rapid Innovation Program comes through the small business community. We could include this as part of the Small Business Innovative Research Program in the future, and that is one of the things we are considering. But before we jump off the cliff, we really would like to have a year's worth of evaluation of the programs to see if we actually got value for money.

Senator HAGAN. How much money did you put out?

Mr. SHAFFER. We got everything out that was appropriated. I am trying to remember. In the first year, it was $200 million, $500 million, somewhere in there, yes.

Senator HAGAN. $400 million?

Mr. SHAFFER. $400 million, yes, ma'am.

Senator HAGAN. Thanks. Ms. Lacey, Ms. Miller, anybody?

Ms. LACEY. We have not completed the first round, but we do have one early completion expected next month, but the vast majority are not going to finish up for another 12 to 18 months.

Dr. WALKER. We put $105 million out to 44 different small businesses working across the rapid response for the warfighter, cyber, sustainment. So far things are looking good and showing promise, and we will see as the program goes on. We are looking forward again to our next round somewhere around 18 to 20 awards coming out this year out of the 2012 money.

The other thing that we are getting out of this is that there is huge interest in the program because we have had over 700 white papers both years that we put out the announcement. So there are a lot of people out there with good ideas that we are able to take a look at and screen through the program.

Senator HAGAN. Ms. Miller?

Ms. MILLER. The Army was the same as well. We have no early indicators yet. We know that we got a lot of interested parties, and it certainly gets connectivity to small business.

Senator HAGAN. Thank you.

Over the years, there also has been much discussion over the pros and cons of various management models of DOD labs that are government-owned and government-operated (GOGO) versus the Department of Energy labs that are government-owned and contractor-operated (GOCO).

So, Ms. Miller, Ms. Lacey, and Dr. Walker, if you were going to start a new basic and/or applied research laboratory, what type of business model would you use for the management and operation of that laboratory? Dr. Walker, why don't we start with you and go back?

Dr. WALKER. I have run two directorates in the Air Force research laboratory and we have pretty much operated under the government-owned with the contractor collaboration with a strong in-house contractor representation. It gives us some flexibility in being able to turn over workforce, identify and bring in new workforce into both the Government and the contractor side and have flexibility as we change the thrust of the research that we are doing at any given time. This has been a very successful model for the Air Force. We studied the GOCO model back in the mid-1990s and we decided to go with the collaborator-assisted model instead, and it has been very successful. I think I would follow that model into the future.

Ms. LACEY. In the Navy, we have a GOGO philosophy which is a little different than the Air Force. However, we do use a significant amount of contractor personnel, perhaps not as fully embedded as you might see in the Air Force. We are very comfortable with our model. We are continuously overseeing how they are doing and ensuring that they are focused on the things that we need them to do and not out there freelancing and creating duplicate capability in their various areas. But as I say, it is something the Navy has become very comfortable with and very good at operating. So it works for us.

Ms. MILLER. The Army model is very much like the Navy model. We are very happy with how we are performing our work.

Senator HAGAN. Thank you.

Go ahead. Ask another question.

Senator FISCHER. Thank you, Madam Chairman.

In my last question, I asked about the infrastructure and the modernization. We did not get to the duplication part.

What kind of process do you have set up that would address if there is unneeded facilities out there?

We talked the other day, yesterday I believe, about programs and how do you keep track of all the programs and the research that you are running to make sure that what the Navy is doing, the Army is further along it, and you really do not need to be doing it. How do you prioritize it? How do you work together? How do you make sure that your efforts are being utilized wisely?

Mr. SHAFFER. I always hate to sound like a Washington bureaucrat and talk process.

Senator FISCHER. But you will. [Laughter.]

Mr. SHAFFER. I will. [Laughter.]

What we have done is reinstituted and strengthened something we call Reliance 21. We are taking a portfolio approach in about 18 of these big areas that all of us have investment in. Now, I can-

not track every one of the 10,000 programs. But we have SES-level members, senior executive service members, in each one of the Services who we charge to get the best that they can out of their program. So we have created a portfolio review with the SESs having to come back to report back to us and tell us what they are doing.

DARPA plays in a slightly different way in this process because we do not want DARPA on any Services' critical path. We want DARPA to disrupt that critical path. So how DARPA plays is they will come in and brief these portfolio managers, and each one is chaired by someone from the Service, brief the portfolio managers on what they are doing so the portfolio managers have that awareness.

But if we cannot trust our SESs to get rid of duplication between themselves, because they are all charged with delivering capability, if we cannot trust our flag-level civilians to drive down duplication, it is very hard for us to do it from the top of the mountaintop.

So this is strengthened. We are in our second to third year of this process. This year we are having the first six of these portfolio managers come back in roughly two half-day sessions brief out their programs to myself, Ms. Miller, Admiral Klunder, Ms. Lacey, and Dr. Walker, and we are going to see how well we are able to drive out duplication. Sometimes you want to have intended duplication, but it has to be a conscious choice. But fundamentally, we have to push that process down to our senior executives to come back and report to us.

Senator FISCHER. Have you ended any programs if you found that there was duplication taking place?

Mr. SHAFFER. I know that programs have ended. Typically when our SESs find out that there is a little bit of duplication, we do not have to end the program. They figure out who is in the lead, who is going to take that piece on so someone else does another portion of the work. These portfolio folks have come back and told us where they have modified their portfolio to get more bang for the buck.

Senator FISCHER. Are you in touch with universities or private industry that is doing research as well and trying to monitor what they are doing and work together or else let one or the other of you move ahead on that project?

Mr. SHAFFER. The answer is yes, and I think Dr. Prabhakar has the best answer.

Dr. PRABHAKAR. I hope I do since I volunteered to try to answer that. [Laughter.]

Senator FISCHER. She had a good one in my office.

Dr. PRABHAKAR. Just following on what Mr. Shaffer was describing as a formal process, a thing I really look to is our core program managers at DARPA to make sure that they know what is going on across the Services but very much, as you said, in the broader technical community. The first way we do that is we recruit program managers who come out of the best parts of the technical community. I think only about 10 percent of my program managers come from other parts of Government. Most of them come from universities or have worked in companies. So they are already from that broader community. Then their day job is to be out and en-

gaged with that community. That is how they build their programs. It is where they get their inspiration for the next generation. They are so personally driven to make an impact with their programs that the last thing they want to do is waste a nickel on something that someone else is already going to do. So that is the bottoms-up part that I think augments what we do as a management team.

Dr. WALKER. From an industry perspective, when we are building road maps, we want industry involved with our road-mapping process so they understand what it is that we are trying to do and what contributions they can make, as well as how they can align their independent R&D to what is important to the government. So it is really a collaborative effort across academia, industry, and the government to ensure that we have the right technology development moving forward to where we want to be in the future.

Senator FISCHER. Thank you.

Ms. Lacey, I was going to ask you about the laser on the ship. This is just for my own personal interest because I read an article on it and it just sounded fabulous. But how is that working out? Can you tell us? What do you think the future holds for lasers?

Ms. LACEY. Ma'am, we would be happy to come in and brief you on this, and if you are ever in Bahrain, we can take you on the USS *Ponce* and show it to you.

We have been working on laser programs collaboratively with our sister Services for decades, and what we are doing is installing this on a ship that is available in theater to do a demonstration against realistic targets again and to understand the operational domain.

But what we are fundamentally trying to do here is prove to ourselves that we have the capability and we can develop the tactics, techniques, and procedures to change the cost equation. We are talking about taking a shot for a dollar as opposed to—yes, whatever it takes to generate the electricity on board that ship to defeat that threat. That is a huge game changer when it comes to the cost equation. As opposed to using a $3 million missile to take out a $50,000 target, we are talking about dollars. It is a big deal. So we have reached the point where we are comfortable that we can put it in an operational theater to learn even more lessons about it.

We would be happy to come show you what we are doing, ma'am.

Senator FISCHER. I may take you up on that. Thank you very much. Thank you all very much. I appreciate it.

Madam Chair?

Senator HAGAN. I know I have a couple more questions, and I am running out of time. So I might submit some for the record for your reply and certainly Senator Fischer too.

Mr. Shaffer, I know that DARPA has just completed its strategic framework. I was just wondering about another strategic framework for your division. I know last year the Defense Science Board (DSB) conducted a study of DOD's basic research portfolio, and one key finding was that DOD needed a technology strategy that would not only be invaluable in alignment of R&E but an alignment of systems, missions, and national security affairs more broadly. Then they listed a vision, an assessment of emerging areas of S&T, particularly areas of rapid change and substantial promise, realistic

objectives, an approach to achieve the vision, and detailed plans on how to achieve the objectives.

Are you developing a more comprehensive strategy with the elements just outlined?

Mr. SHAFFER. Senator Hagan, a couple of things.

The short answer is yes, but not at the detail listed in the DSB report. I commented that I do not like a lot of bureaucracy.

One of the other things I will note in Washington is more is written than is ever read.

Senator HAGAN. I agree with that.

Mr. SHAFFER. So this strategy that is outlined by the DSB is really an implementation plan. We have developed a strategy and we are waiting to see what happens with the political process. But the strategy that I have written is very much like DARPA's framework. It is a very short document that outlines where we want to go and the tools that will be available to the people.

Following from that, the rest of these things that are in the DSB report is really an implementation plan, and that should be pushed down to the people who actually are going to execute the program to come back up and tell us. So these things that are in this plan are in those portfolio managers' responsibilities that I just mentioned.

We are on the path. We are not there yet. I have a strategy drafted. I have shown it to Mr. Kendall, the Under Secretary, and now we are just waiting to see what happens with all the political process.

Senator HAGAN. Thank you.

Mr. SHAFFER. Yes, ma'am.

Senator HAGAN. To all of our witnesses, I really do appreciate your time, the service that you give to our country, and in particular, the detail, the approaches for the long-term using the technology that you are developing right now. I think it is very, very important to our country, to the warfighters, and to the national security. Thank you for being here.

This hearing is adjourned.

[Questions for the record with answers supplied follow:]

QUESTIONS SUBMITTED BY SENATOR KAY R. HAGAN

OVERSIGHT OF LABORATORY PERSONNEL

1. Senator HAGAN. Mr. Shaffer, the Department of Defense (DOD) Laboratory Quality Improvement Program (LQIP) established in 1993 seeks to improve the efficiency of the labs by streamlining their business practices and granting the heads of the labs increased authority to operate their organizations in a business-like fashion. One of the outcomes of LQIP was the creation of a panel to provide recommendations on DOD lab personnel issues. Currently, the LQIP panel for personnel falls under your oversight. What has this panel recently accomplished?

Mr. SHAFFER. The LQIP Personnel Panel is the most active group within the LQIP and meets quarterly to exchange best practices and experiences on the variety of unique authorities given to each lab. The most notable accomplishment of the panel is its contribution to the implementation of expanded direct hiring authority for scientists and engineers with advanced degrees. Also, through the efforts of the LQIP Personnel Panel, 95 percent of the defense laboratory workforce is included in a Science and Technology Reinvention Laboratory also known as "Demonstration Program" personnel program as of the end of fiscal year 2012. In addition, the Personnel Panel was instrumental in gathering data and assisting in analysis of information in support of the soon to be submitted DOD Human Capital Workforce Strategic Plan.

2. Senator HAGAN. Ms. Miller, Ms. Lacey, and Dr. Walker, what are your views on the effectiveness of the LQIP and should there be other panels under LQIP, for instance, for laboratory infrastructure?

Ms. MILLER. The Laboratory Quality Enhancement Program (LQEP) (formerly the Laboratory Quality Improvement Program) is restarting after being dormant for more than a decade. While the main program has been dormant, a subpanel of the program focused on the Science and Technology Reinvention Laboratories has been very active and effective at addressing issues related to the Laboratory Demonstration Program. There has been continuing dialog amongst the LQEP members with regard to initiation of additional subpanels, to include one on laboratory infrastructure. However, no additional subpanels have been chartered. LQEP members do see value in having subpanels meeting at the working level to address focused issues prior to senior leader engagement and decisionmaking.

Ms. LACEY. LQIP provides a forum for the Department of Navy to collaborate with our sister Services to address issues of long-term sustainability of our research and development infrastructure. The cross Service nature of this panel allows the Navy to consider common approaches to shared issues such as streamlining authorities, infrastructure investments, and workforce revitalization that affect all DOD labs.

The LQIP already allows the sharing of best practices and lessons learned that impact all DOD laboratories. As currently structured, the LQIP is an effective forum for the exchange of ideas and information and does not need to be expanded beyond the existing panel.

Dr. WALKER. The LQIP is now known as the LQEP. Over the last 2 decades, the LQEP has provided a means for the Air Force Research Laboratory (AFRL) and the other DOD laboratories to articulate and propose approaches to address problems that are unique to the laboratory community. For example, the Personnel subpanel has been vital to the continued success of the demonstration project authorities by focusing on the mission and associated needs of each individual laboratory. The subpanel's efforts have resulted in authorities and legislation that have provided AFRL the control and flexibility needed to manage its workforce and improved and strengthened AFRL's ability to compete for critical personnel.

The LQEP no longer has a dedicated subpanel to address laboratory infrastructure issues; however, the panel as a whole continues to work common infrastructure issues among the laboratories. This approach is working well. With resources at a premium—both personnel and dollars—the Air Force does not recommend the establishment of a separate infrastructure subpanel at this time.

[Whereupon, at 3:54 p.m., the subcommittee adjourned.]