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ON

NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2012

AND

OVERSIGHT OF PREVIOUSLY AUTHORIZED PROGRAMS

BEFORE THE

COMMITTEE ON ARMED SERVICES
HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES HEARING

ON

BUDGET REQUEST FOR DEPARTMENT OF DEFENSE SCIENCE AND TECHNOLOGY PROGRAMS

HEARING HELD
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FISCAL YEAR 2012 NATIONAL DEFENSE AUTHORIZATION BUDGET REQUEST FOR DEPARTMENT OF DEFENSE SCIENCE AND TECHNOLOGY PROGRAMS

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES,
Washington, DC, Tuesday, March 1, 2011.

The subcommittee met, pursuant to call, at 3:05 p.m., in room 2212, Rayburn House Office Building, Hon. Mac Thornberry (chairman of the subcommittee) presiding.

OPENING STATEMENT OF HON. MAC THORNBERRY, A REPRESENTATIVE FROM TEXAS, CHAIRMAN, SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

Mr. THORNBERRY. The hearing will come to order.

Let me welcome Members and witnesses and guests to this hearing of the Emerging Threats and Capabilities Subcommittee on DOD's [the Department of Defense's] fiscal year 2012 budget request for science and technology programs.

We are expected to have some votes shortly. My hope is we can at least get all the witness statements in before that time and hopefully beyond that. But in light of time constraints, I will certainly be brief.

I think most of us would agree that the programs that are the subject of today's hearing are the future of the Department of Defense and, in many ways, of our country's security. And yet, with tight budgets, they are always in danger of being squeezed, because you often don't see the consequences of those reductions immediately. And so the temptation is always there to cut our future, and that, in my view, would be a dangerous thing.

The administration's fiscal year 2012 request for the programs before us today is $12.2 billion. I understand if you look across the FYDP [Future Years Defense Plan], there is about a 2-percent increase in basic research. But across the FYDP, the rest of the accounts are essentially flat. I have some concerns about that. But it is important, I know, for all of us to keep the total budget in perspective. But that is an area we may want to explore more.

Obviously, all of your written statements will be made part of the record. And I appreciate a number of the examples you have given us in those written statements. And we will explore more of those in questions.

At this time, I would yield to the ranking member for any comments he would like to make.

STATEMENT OF HON. JAMES R. LANGEVIN, A REPRESENTATIVE FROM RHODE ISLAND, RANKING MEMBER, SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

Mr. LANGEVIN. Thank you, Mr. Chairman.

And I want to express my thanks to all of our witnesses here today.

Let me just say that I firmly believe that the continued strength of our Nation is reliant upon our ability to continue to lead the world in innovation and advanced research and development. From GPS [Global Positioning System] to the Internet, we are all aware of the benefits that investments in defense science and technology have had on our daily lives. But what is sometimes overlooked is the remarkable impact these programs have on our national economic and educational competitiveness, as well.

Now, the goal of these programs is to invest in emerging science that will become the backbone of tomorrow's fighting force. To do this, however, the United States must maintain a strong research and development capability housed inside and outside of government by partnering with industry and academia.

For example, 60 percent of the Department's basic research investment, $1.2 billion, goes directly to local universities to promote projects advancing knowledge and understanding across a wide array of fields, from advanced mathematics to environmental sciences. These programs not only have a vital national security benefit, but are a critical source of funding to keep the U.S. leading in the world in academic research and development. Similarly, the Department devotes the majority of its remaining science and technology budget to support defense laboratories and industry research efforts, as well.

While much of these funds goes to support larger contractors and corporations, the Department also makes targeted investments in small businesses that specialize in specific high-technology research and development efforts. These smaller partners provide critical technology that is often too narrow and highly specialized for larger companies to consider.

Because of their size, small high-tech companies can often complete specific research and development projects faster and more efficiently than larger contractors positioned to handle major large-scale programs. Now, these small businesses are excellent tools in achieving great efficiencies in the Department's science and technology efforts, and I certainly commend the Department for recognizing their importance.

I have, however, been troubled that our efforts in Congress to authorize initiatives like the Small Business Innovation Research, or SBIR, Program and the Mentor-Protégé Program have fallen, in many ways, by the wayside. With that in mind, I hope that our panel will address specific efforts to increase outreach and partner with academia and small businesses.

With that, I would certainly look forward to hearing your testimony, and I want to thank our witnesses for being with us today.

Thank you.

[The prepared statement of Mr. Langevin can be found in the Appendix on page 39.]

Mr. THORNBERRY. I thank the gentleman.

We will now turn to our witnesses. We have the Honorable Zachary Lemnios, Assistant Secretary of Defense for Research and Engineering; we have Dr. Marilyn Freeman, Deputy Assistant Secretary of the Army for Research and Technology; Rear Admiral Nevin Carr, Chief of Naval Research; Dr. Stephen Walker, Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering; and Dr. Regina Dugan, Director of Defense Advanced Research Projects Agency, known as DARPA.

Mr. Secretary, the floor is yours.

STATEMENT OF THE HON. ZACHARY J. LEMNIOS, ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING, U.S. DEPARTMENT OF DEFENSE

Secretary LEMNIOS. Good afternoon, Chairman Thornberry, Ranking Member Langevin, and committee members.

I ask that my written testimony be entered into the record.

Before I outline our plans for next year, it is important that I comment on the effects of the year-long continuing resolution or a reduction in the fiscal year 2011 budget request. To echo Secretary Gates, either of these scenarios would create a crisis in the Department, including the research and engineering enterprise.

We need the funds in the fiscal year 2011 request for existing and planned programs to develop the capabilities our troops have simply asked for and to ensure that many of our small businesses who develop those capabilities in fact stay in business. Operating under a long CR [continuing resolution] or well below the President's fiscal year 2011 budget request puts both at risk and results in both the loss of valuable time and the ability to support our troops.

As the Department's chief technology officer, I want to thank you for the opportunity to tell you about the important work that the dedicated men and women in the Department of Defense research and engineering enterprise perform every day to support our Nation's security.

This enterprise encompasses a remarkable pool of talent and resources. Our footprint includes 67 Department laboratories dispersed across 22 States, with a total workforce of 60,000 employees, 36,400 of which are degreed scientists and engineers who publish thousands of papers in peer-reviewed journals and keep the Department at the forefront of technology.

We operate 10 federally funded research and development centers, 13 university-affiliated research centers, and 10 information analysis centers across critical disciplines for the Department, supporting the combatant commanders in all disciplines.

Their successes would not have been possible without Congress' help, and you have my heartfelt thanks for your steadfast support of our programs.

We are in a period of remarkable change. Innovation, speed, and agility have taken on greater importance to our efforts, given globalized access to knowledge and to the rapid pace of technology development.

In this environment, it is critical that we first operate with urgency to meet the immediate needs of our warfighters; that we prepare for the future by establishing the technical foundations for in-

novative, new capabilities for the operational missions described in the Quadrennial Defense Review and remain on a constant lookout for opportunities to create and avoid technology surprise; and to assure that we have the supply of science, technology, engineering, and mathematics capabilities across the Department.

We are strategically shaping this enterprise to address these challenges. The Department's science and technology investments are well-coordinated, they are focused on high-quality research efforts, and they are responsive to the current and future warfighter needs.

The Department's research and engineering enterprise is structured around the following four imperatives:

First, to accelerate the delivery of technical capabilities to win the current fight. We remain responsive to the urgent operational needs of our combatant commanders. For example, in Afghanistan, the Army's Research, Engineering, and Development Command leverages a network of science and technology teams and advisors to collect and distribute firsthand knowledge of warfighter needs across the Department. I have seen this, and I will tell you the result is remarkable.

Second, we need to prepare for an uncertain future. In 2010, we established the Department's Science and Technology Executive Committee, which I chair, which includes all of my colleagues here today. This committee identified seven priority areas for investments that would provide dominant technical advantage across the mission space for the near- and far-term needs of the Department. Our programs in basic research and technology watch have been restructured to ensure our scientists are involved early in potentially shaping disruptive emerging science areas to great advantage to the Department and to the Nation.

Our third imperative is to reduce the cost, the acquisition time, and the risk of our major defense acquisition systems. Last year, the Department implemented new systems engineering policy and guidance to drive better technical performance for the Department's acquisition programs. This included the trusted defense system strategy to streamline, to update, and to apply program protection and supply-chain risk-management policy guidance and methods.

And our fourth imperative is to develop world-class science, technology, engineering, and mathematics capabilities for the Department and for the Nation. We realize that our technical goals are only achievable with exceptional research and engineering talent. And our STEM programs have provided the resources and the strategy to train and recruit the workforce we need in the future.

We continue to foster a strong relationship with future scientists and engineers. Our STEM efforts have reached out to over 180,000 students, 8,000 teachers across the country. Our Science, Mathematics, and Research to Transformation, or our SMART Program, funds 670 undergraduate, graduate, and doctoral students in 19 DOD-relevant fields of study.

This is the Department's research and engineering enterprise and our focus. Mr. Chairman, thank you for the opportunity to present these remarks. With congressional support for the President's budget, the research and engineering enterprise will have

the resources it needs to ensure a strong technical base to enhance the Nation's security.

I look forward to your questions.

[The prepared statement of Secretary Lemnios can be found in the Appendix on page 40.]

Mr. THORNBERRY. Thank you. I appreciate it.

Dr. Freeman.

STATEMENT OF DR. MARILYN FREEMAN, DEPUTY ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH AND TECHNOLOGY, U.S. ARMY

Dr. FREEMAN. Chairman Thornberry and the distinguished members of this subcommittee, I want to thank you for your steadfast support of our soldiers who are now at war and for your support of Army S&T [science and technology] investments that will continue to assure technological preeminence for our soldiers in the future. Your continued advocacy is essential for our success.

I appreciate this opportunity to discuss the fiscal year 2012 Army Science and Technology Program and the significant role that Army S&T has in supporting our warfighters. I have submitted a written statement and request it be accepted for the record.

I assumed the role of Deputy Assistant Secretary of the Army for Research and Technology in July of 2010. I came to this job with over 30 years of experience in various positions in Army S&T and in DARPA.

I am privileged to represent a cadre of over 12,000 scientists and engineers who are dedicated and are highly skilled in their jobs, who comprise the Army S&T community. My mission is to revitalize Army S&T, to foster better discovery, invention, innovation, and demonstration of technologies, both for the current and the future.

We are ever mindful that our technologies and systems are tools that we provide the men and women who voluntarily put themselves in harm's way for our country. As a result of the past 10 years of war, the Army has rediscovered the fundamental precept that the soldier, operating as part of a small team or combat unit, is our decisive weapon.

This has led us to consider a different approach to S&T, in which our focus is shifting from big platforms and large systems to more soldier-centric solutions. We must provide technology-enabled capabilities that empower, unburden, and protect our soldiers.

While Army S&T has always provided new capabilities and enhancements to our existing capabilities, it is time that we step up our game and focus on results that will get the most needed advanced capabilities to our soldiers more quickly and more affordably than ever before. I believe that the fiscal year 2012 S&T budget we have submitted will enable us to accomplish this task.

I am convinced that in a fast-paced, complex global economy, Army S&T needs to be better focused, more accountable, and more transparent than ever before. To that end, I have already begun to reshape my headquarters organization to better serve the needs of the soldier and to ensure that Army S&T is the go-to place for Army senior leadership on all S&T and engineering issues.

I am also reorganizing the management of our investments to allow for better oversight and a more holistic perspective across all of our lines. We are organizing our program into four portfolios: soldier; ground; air; and command, control, and communications. Now, included in these are all of the items and areas with which you are familiar, including lethality, survivability, medical research, training, and manufacturing technology.

By organizing our enterprise in this way, we are able to manage each portfolio in terms of far-term, basic research; midterm, applied research; and near-term, advanced technology development. My written testimony provides some specific details on the efforts in each portfolio.

Especially in this constrained budget environment, Army S&T must better synchronize our programs and major efforts with fiscal processes and timelines determined by the needs of the warfighter. In the coming months, I will be working with the Army senior leadership, our partners in TRADOC [Training and Doctrine Command], the program executive offices, and the leaders in our S&T labs and centers to develop a list of top-priority issues or problems that require S&T to close gaps.

This list will be used to shape our S&T programs with quantified objectives for the near term and will help us better focus our applied and basic research efforts, as well. This set of clear priorities will help us to be more effective in reaching out to industry, to other services, to academia, and other government agencies to identify partnership and leveraging opportunities.

The health and long-term viability of our labs will be one of our major challenges in the years to come. We have long worked to make improvements at the margins, and, where possible, we have used the BRAC [Base Realignment and Closure] process to modernize facilities and infrastructures. But this not a long-term solution. Over the coming year, I intend to take an in-depth look and look forward to working with you to help fix this problem.

In closing, thank you, Mr. Chairman, for the opportunity to testify before this subcommittee and for your support to Army science and technology. I look forward to working with you and am happy to answer any questions.

[The prepared statement of Dr. Freeman can be found in the Appendix on page 60.]

Mr. THORNBERRY. Thank you.

And I appreciate both of you all keeping your oral comments pretty close to 5 minutes. With the number of witnesses and Members we have, that is a challenge, and I appreciate that very much.

Admiral, please proceed.

STATEMENT OF REAR ADM. NEVIN P. CARR, JR., USN, CHIEF OF NAVAL RESEARCH, U.S. NAVY

Admiral CARR. Thank you, Mr. Chairman.

I am joined today by my deputy, Marine Corps Brigadier General Bob Hedelund, who is right behind me.

It is an honor to report on science and technology efforts within the Department of the Navy and to discuss how the President's fiscal year 2012 budget request supports the Navy and the Marine Corps.

The Office of Naval Research works closely with the Secretary, Chief of Naval Operations, and Commandant of the Marine Corps to address critical challenges to ensure that we focus on S&T areas that provide the biggest payoff for the future, embrace innovative thinking and business processes, and maximize transition of S&T products into acquisition programs and commercial use.

We do this in the most efficient and effective manner possible to strike that right balance between responsive, near-term technology insertion and unfettered, long-term, innovative basic research. It is that latter category that holds the greatest potential to provide the underpinnings for game-changing disruptive technologies like GPS, electromagnetic railgun, and free-electron laser.

There are many Navy S&T products in use today, with many more on the way. They may not always be highly visible, but they are there, from better paint to lifesaving medical advances and energy-saving technologies.

Among our greatest challenges is helping ensure students pursue and succeed in science, technology, engineering, and math disciplines. This is critical to the future quality of our S&T workforce and our global competitiveness. The United States is the world's technology leader, but we must continue to support a strong S&T base if we are to maintain that position, especially in the face of current global trends.

As Chairman of the Joint Chiefs, Admiral Mullen, testified recently, one of the ways you protect against the unknowns is to make sure that S&T and pure R&D [research and development] budgets are both comprehensive and broad. You need that innovation. You need the investment for capabilities of the future that starts there.

The country's R&D effort is being driven increasingly by industrial and commercial demand. In 1960, 75 percent of all U.S. R&D was government-funded. Today, that proportion has dropped to 25 percent. And contained within that decreasing 25 percent is the higher-risk basic research that may not provide the ROI [return on investment] that industry demands. This further underscores the importance of our S&T portfolio and especially that portion dedicated to basic research. This is our seed corn.

As a measure of research quality, the Institute of Electrical and Electronics Engineers, the IEEE, recently ranked the U.S. Navy's patent portfolio as the strongest of any government organization in the world. Quality is important, but so is depth.

Transition of S&T products to warfighters is our critical metric, and we track every single product to ensure we maximize that transition. We understand and correct the causes of failure when it does occur. Strong S&T investment is about managing risk. If every product transitions easily, we are not out there far enough pushing the edge of technology.

At about 75 percent, our current transition rate represents a good balance between risk and payoff. Even so, many transitioning technologies wouldn't be ready today without those basic research investments that were made 20 to 30 years ago.

We focus much of our investment on industry and academia within this country and around the world in order to tap the full measure of innovation, to push for technologies that have commer-

cial application, where possible. For example, algorithms developed for sonar signal processing are now helping to reduce breast cancer detection rates. And our active Small Business Innovation Research partnerships generate new jobs across the country while increasing innovation and competition.

The President's 2012 budget request will help the Navy and Marine Corps benefit from carefully considered technology investment and build on strong partnerships among the services, OSD [the Office of the Secretary of Defense], and throughout government and partner countries. I believe the state of our S&T investments is sound, represents good stewardship of taxpayers' dollars, and enhances significantly the safety and performance of our warfighters today and well into the future.

Thank you again for your support, and I look forward to answering your questions.

[The prepared statement of Admiral Carr can be found in the Appendix on page 73.]

Mr. THORNBERRY. Thank you, Admiral.

Dr. Walker.

STATEMENT OF DR. STEVEN H. WALKER, DEPUTY ASSISTANT SECRETARY OF THE AIR FORCE FOR SCIENCE, TECHNOLOGY, AND ENGINEERING, OFFICE OF THE ASSISTANT SECRETARY FOR ACQUISITION, U.S. AIR FORCE

Dr. WALKER. Mr. Chairman, members of the subcommittee, and staff, I am pleased to have the opportunity to provide testimony on the fiscal year 2012 Air Force Science and Technology Program.

The Air Force fiscal year 2012 President's budget request for S&T is approximately $2.3 billion, which includes an increase of $95 million, or 2.8 percent real growth, from the fiscal year 2011 budget. This increase reflects the Air Force leadership's steadfast support for its S&T program even in the face of a very challenging fiscal environment.

A lot has happened since I testified here about a year ago as the brand-new S&T executive for the Air Force. I have enjoyed this new role and the many challenges and opportunities it has provided. It has been busy, but we have gotten a lot done.

I am pleased to say that, this past year, the Air Force has developed and published an S&T strategy, the first of its kind since 2004; created a collaborative S&T planning process that maintains a balanced technology push from the laboratory and a technology pull from the warfighter.

The Air Force S&T Program provides the foundation for the majority of the Air Force's strategic priorities. These strategic priorities, along with the input from the warfighter, our S&T vision as articulated in Technology Horizons, and our S&T strategy inform our new S&T planning effort to help shape our future investments.

The S&T planning process, which was created over the past year with extensive participation from across the Air Force, provides a framework for the major commands, the product centers, and the Air Force Research Laboratory to work collaboratively to identify and understand both technology needs and potential solutions.

The Air Force's S&T fiscal year 2012 President's budget request supports four overarching priorities detailed in the strategy. I would like to discuss those with you briefly.

Priority 1 is to support the current fight while advancing breakthrough S&T for tomorrow's dominant warfighting capabilities. We must invest in S&T that will enable the Air Force to operate effectively and achieve desired results in all domains and operations, both today and in the future.

The Air Force Rapid Reaction and Innovation Process, known as Core Process 3, is designed to tightly integrate S&T knowledge with operator knowledge to deliver solutions to the warfighter in 12 months or less. In the past year, we have developed several quick reaction solutions, one recently to Air Mobility Command, single-pass airdrop capability for Air Mobility Command.

It is also important to note that we also create technology options for the future. We have increased basic research funding by $18 million to focus on far-term priorities, as well. For example, efforts are under way in our Robust Scramjet program that will support future long-range strike and operationally responsive space access solutions.

Priority 2 is to execute a balanced, integrated S&T program that is responsive to the Air Force service core functions. This priority essentially speaks to where we will invest our next S&T dollar.

We have established a program element for sustainment that is dedicated to developing and demonstrating technologies to address operational sustainment issues in existing systems as well as supporting new systems. We are investing resources toward emerging warfighter concepts; supporting the needs of the nuclear enterprise; reducing our vulnerabilities to cyber attack; evolving our intelligence, surveillance, and reconnaissance capability; demonstrating long-range strike technologies; and investing in a diverse energy technology portfolio.

We are also tapping innovative ideas from small business to help us in all these efforts.

Priority 3 is to retain and shape the critical competencies needed to address the full range of S&T product and support capabilities. Said another way, we must have a dedicated, educated, and highly skilled workforce of scientists and engineers. And toward that end, we are actively seeking to improve our intramural basic research program and increase our organic cyber workforce.

We are also supporting Air Force science, technology, engineering, and mathematics initiatives to develop and optimally manage the S&E [science and engineering] workforce of the future. "Bright Horizons," an Air Force STEM [science, technology, engineering, and mathematics] strategic roadmap for shaping the way the Air Force manages its mission-critical STEM capabilities, is currently in coordination and is expected to be signed this spring.

Finally, Priority 4 is to ensure the Air Force S&T Program addresses the highest-priority capability needs of the Air Force. And as part of that, we established this S&T planning process and created something called the "flagship capability concept." These are Air Force-led demonstrations of capability.

The Vice Chief has recently endorsed three: a high-velocity penetrating weapon, a reusable space access program, and a cyber pro-

gram that I can talk about later. These three programs will be at the forefront of where the Air Force Research Laboratory goes in demonstrating new capability for the warfighter.

In conclusion, the Air Force S&T Program is balanced to address warfighting needs, both near-term and far-term. By focusing on the S&T priorities documented in the recent strategy and utilizing the new Air Force planning process to listen and respond to the warfighter, the Air Force S&T Program will continue to provide the technological edge needed to win today's fight and prepare for tomorrow's challenges.

Mr. Chairman, thank you again for the opportunity to testify today, and thank you for your continued support of the Air Force S&T program.

[The prepared statement of Dr. Walker can be found in the Appendix on page 89.]

Mr. THORNBERRY. Thank you.

Dr. Dugan.

STATEMENT OF DR. REGINA E. DUGAN, DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY, U.S. DEPARTMENT OF DEFENSE

Dr. DUGAN. It is said that vision without execution is daydreaming. There is a time and a place for daydreaming, but it is not at DARPA. DARPA is a place of doing. For 50 years, our doing has been the creation and prevention of strategic surprise.

Today I would like to focus on a few examples that characterize the breadth of activities at the Agency. They are intended to open the door for an ongoing exchange.

Chairman Thornberry, Ranking Member Langevin, members of the subcommittee, my name is Regina Dugan. I am the director of DARPA, and I am honored to be here.

Submitted for the record in support of our budget request is the Agency's full testimony.

If I am able to leave you with only three key takeaways, this is what I would like you to know:

First, strategic surprise does not conform to a predetermined timeline. Sometimes it requires 5 to 10 years, sometimes only 90 days.

This spectrum is revealed most vividly in our support to operations in Afghanistan. Within 90 days, a Skunk Works® [Lockheed Martin Advanced Development Programs] effort yielded advances in computational techniques; an analysis cell went to ISAF [International Security Assistance Force] Headquarters 3 weeks later. We stood up a forward operating cell. Three months later, a wide-area LIDAR [light detection and ranging] system 5 years in the making was providing 3D [three-dimensional] maps to users. At full operational capacity, the HALOE [High Altitude LIDAR Operations Experiment] system can map 50 percent of Afghanistan in 90 days, whereas previous systems would have required 3 years.

Second, efficiency is, of course, the ratio of output to input. Speed and leanness are important to the input. Choosing among ideas is the challenge for output. And, frankly, that is the hard part.

Speed is part of the vibrancy of innovation, and the absence of bureaucracy is a brand attribute of DARPA. In the last year, our

contracting time has been reduced by 20 percent. And, by September, improved execution had put 600 million more to work for defense and in the economy than in any of the 5 years prior. We have had the same number of program managers since 1992.

The output side is governed by how we choose. The real challenge at DARPA is not generating ideas, it is choosing among them. To address this challenge, we have developed several deeply quantitative analytic frameworks. Through them, we ask: Where are the opportunities to effect changes not in the margins but in big, bold strokes?

As an example, the time required to design, test, and build complex defense systems has grown from 2 years to more than 10. We simply must improve our ability to make things. Our Adaptive Make program seeks to bring manufacturing advances like those realized in semiconductor, software, and protein production to defense systems. The goal? Compress the time to field military ground vehicles by a factor of five.

There is no issue more fundamental to the Nation's defense and competitiveness than this because to innovate, we must make, and to protect, we must produce.

Finally, current approaches to cybersecurity are necessary, but they are divergent with an evolving threat. This calls for aggressive R&D, and we are stepping up to the challenge.

Over the last 20 years, security software has increased from thousands of lines of code to over 10 million lines of code. By contrast, malware has remained at a near-constant average of 125 lines of code. Ten million versus 125. It is like being in the ocean and treading water; you must, but if that is all you do, eventually you will drown. We need new options. So we recruited an expert team, increased our investment, and launched several new initiatives.

Three key takeaways then: DARPA's singular mission is the creation and prevention of strategic surprise, which can happen over a decade or in 90 days. Choosing among alternatives is where we realize big payoffs in effectiveness. This is highlighted by our need to improve manufacturing, because to innovate, we must make, and to protect, we must produce. And finally, current approaches to cybersecurity are divergent with an evolving threat. We need new options.

This past year was one of vision paired with execution. Chairman Thornberry, Ranking Member Langevin, and members of the subcommittee, I thank you for your support, and I look forward to your questions.

[The prepared statement of Dr. Dugan can be found in the Appendix on page 110.]

Mr. THORNBERRY. Thank you, Doctor.

And let me thank you all again for condensing down. I know you have a lot to say, and I know it is hard to do that in a five-minute period, but I am grateful, for the reasons I have indicated.

It also occurs to me, as I survey the table there and read up on your credentials, your experience, the country is very fortunate to have each of you in the positions you are. Each of you could be making a whole lot more money doing other things, and we are

grateful that you and the folks who work with you are doing what you are doing.

I am going to yield my 5 minutes to the gentleman from Pennsylvania, Mr. Shuster, to go first.

Mr. SHUSTER. Thank you, Mr. Chairman.

And I appreciate all of you being here today. And I agree with what the chairman said. A lot of firepower, brain power out there, and we certainly appreciate what you do for our Nation.

First, Dr. Dugan, you made the comment, you have had the same number of project managers since 1992. Is that accurate?

Dr. DUGAN. That is correct.

Mr. SHUSTER. How have you been able to do that? You are probably the only department in the Federal Government that is able to make that claim.

Dr. DUGAN. Yeah.

Mr. SHUSTER. How have you been able to do that? Is it innovation? I mean, what goes on over there that keeps you at that level and keeps you continuing to produce a high level of work?

Dr. DUGAN. Program managers at DARPA come for a tour that lasts about three to five years. They run projects at the Agency with a similar time period. And so, many scientists and engineers view their time at DARPA as their service to country. And, as a result, we have a constant influx of new ideas, new expertise, and so on.

Mr. SHUSTER. Well, I guess that is something we can learn throughout the government, how to do that. So I appreciate that.

Mr. Lemnios, you and I have discussed before a program that is out there, FirstLink, that works with the Department's science and technology efforts, its research activities, working with all branches, including the Defense Office of Technology, Air Force Research, the Navy, the Army Research Laboratory. And their mission is to accelerate the rate that technologies from the Pentagon laboratories are transitioned into commercially viable application for you and for first responders.

And we had the discussion, and I wanted to know what the status of that program—they have done a great job of moving those technologies forward and giving back money to the Department of Defense, so they are working at no cost. So I wondered what is going on with those programs and what do you view the future of that type of program.

Secretary LEMNIOS. Well, Representative, that program is not in the President's fiscal year 2012 budget, but we have looked broader at how we could incorporate those concepts as part of the Small Business Programs, and we are doing just that. In fact, the Innovative Research Program that was in the authorization bill—the funding, actually, doesn't track it yet—is part of that thinking.

And what we have done broadly across the SBIR program is look at how we can pull ideas out of that community, couple those with the warfighter and with the service needs, and do that more effectively. In fact, just this last month, we looked at our Phase I and Phase II efforts that were currently funded. We have identified a number of projects, and we are looking at how we could accelerate those to the next phase.

So we are trying to take what came out of the FirstLink effort and really broaden it across the Department in some other efforts.

Mr. SHUSTER. And I am not sure I understand that thinking, at this point in time, when, you know, we are looking at budgets, we are looking at ways to save money.

When you have a program that has returned $6.5 million back to the Department of Defense, why are we cutting it out at this time? Why wouldn't we be looking at these? And there are other companies out there that are doing the same sorts of things. Why are we doing that?

And that is why I started off my first question to Dr. Dugan, about how they are able to perform at such a high level with the same numbers. It just seems to me that this administration wants to bring things in-house that doesn't always have a positive outcome when it comes to the bottom line, when it comes to producing things quickly.

So how does that logic work in this case?

Secretary LEMNIOS. Well, I can tell you that, with regard to our small-business community that we care deeply about, that the ingredient there is to be more informative with that community in terms of what our Department needs are and to try to couple those efforts earlier on into that process.

And, in fact, last year, at this hearing, I took a question from Congresswoman Sanchez on exactly that topic, in terms of how do we more effectively couple that. I think I sent you a note just recently in terms of how we would do that with regard to the FedBizOpps [Federal Business Opportunities] portal.

So we are looking at the broad issues of how do we couple the small-business community into this enterprise. We looked across our budget and our programs. And as part of that, we think that there is a broader way to address that issue.

Mr. SHUSTER. So, $6.5 million over the past couple years, you have decided that has not been a good return for you on it. And, again, I talk to the small-business community all the time and am involved in an effort right now where the small-business community across DOD feels as though they are not getting a fair shake. And that is where many of these ideas come from. So it just seems to me, cutting out something like this that has had a good return is going about it in the wrong way, especially when we are looking at reducing budgets or finding savings in the Department of Defense.

I see my time is ready to expire. So I will be watching closely, and I am sure we will be communicating to see what happens here. And I have great doubts that we are going to see this kind of success by moving it into the—by the Department.

Thank you, Mr. Chairman.

Mr. THORNBERRY. Obviously, they just called votes, but I will yield to the ranking member to ask his questions, and then we will come back immediately after the last vote.

Mr. Langevin.

Mr. LANGEVIN. Thank you, Mr. Chairman.

Again, thanks to our panel for your testimony today.

Let me start with Secretary Lemnios.

Secretary, in the Fiscal Year 2011 Defense Authorization Act that passed the House and the Senate earlier this year, the committees directed the Secretary of Defense to establish a competitive, merit-based rapid innovation program to accelerate the transitioning of promising technologies into actual defense acquisition programs. The funding of this initiative was included in the continuing resolution we sent to the Senate, but obviously hasn't passed into law just yet.

The language in the bill provides large leeway for the Department to select promising projects under this program, from SBIR Phase II, defense laboratories, and other innovative initiatives.

I think everyone on the committee would be interested in hearing how the Department plans on administering the program once it is funded.

And I believe that funding for this program was appropriated for each of the services, as well, so I would welcome, of course, the comment from the other witnesses on this topic.

Secretary LEMNIOS. Congressman, thank you for the question. That was exactly the program that I referred to earlier. In fact, we have gone through and looked at our SBIR programs to identify those that have a direct connection to combatant needs. Over the course of the last several months—in fact, we started this process last August, when we had our first discussions on this topic.

We have identified a number of Phase I and Phase II efforts that are far enough into the process that we ought to be transitioning those to end-user needs. And we are looking at how we might do that within our existing authorities and existing budget, short of an H.R. 1 passing.

So I would agree with you that there are some low-hanging fruit. We have identified a few of those. And we will be working over the next several months, responsive to the statute, to come back with a plan that supports this broadly across the Department.

Mr. LANGEVIN. Thank you.

Other witnesses' comment on this?

Admiral CARR. I would just add that we get great leverage out of the SBIR program and we rely it. We have about a little over a thousand relationships with industry, in terms of our basic and applied research, and over 800 of those are with small business. Not all of those are through SBIR, but we very rely heavily on small business and want to do what we can to keep the relationship strong.

Dr. WALKER. On the Air Force side, we are interested in getting more money into sustainment. And so we have thought about using some of the money in that fund for small business to participate in answering needs from our air logistics centers. Because we would like to get—and I think the opportunities to transition and commercialize small-business activities on the sustainment side is huge, and we haven't taken great advantage of that, up to this point. So I would use some of that money for that.

Dr. FREEMAN. And on the Army side, you know, we also have lots and lots of experience and good results coming out of both Phase I and Phase II, about $475 million in the Army in this program. And we remain committed to execute this program.

And part of what I am looking at for the Army is for the Army SBIRs, how to streamline the process a little bit better in the way we actually select the programs and actually go forward with selecting programs. And part of that process, I want to look at those that are Phase II and match them up with, as I talked about, some of those big ideas and big Army challenges that we have, closing gaps, and be able to identify those that are really high payoff, big promising, to fill some of those gaps.

And I would use the money to be able to accelerate those and get those into, essentially, Phase III and transition those programs either into National Stock Number-type items or into acquisition programs of record.

Dr. DUGAN. I will just comment on our engagement with small businesses generally.

So, above our approximately 2.8 percent mandate in SBIR, the Agency funds approximately threefold that amount to small businesses. Our engagement with them is focused not only on getting them resources but also increasing our speed to get them under contract, because speed is so important to small businesses, and, as well, simplifying our approach.

So, as I mentioned earlier, our contracting time is down by over 20 percent, at this point, with small businesses. We have reduced our contract vehicle from approximately a 50-page contract to a 10-page contract. And we have conducted, over the last year, two industry summits. We have had more than 200 companies in; 70 percent of those companies were small businesses. They represent 16 different segments from 30 different States.

So our engagement with the small-business community from DARPA is very robust, both in terms of the ideas that they bring and, as well, their performance in our portfolio.

Mr. LANGEVIN. Thank you.

My time has expired, but let me just say that there are so many incredible small businesses out there that have these innovative products to offer and, as you pointed out, have been effective at making sure that some of them have been brought to the warfighter very effectively that otherwise might have been ignored by big business. And we need to do more. I haven't been satisfied that SBIR has functioned as it really was intended and hasn't been as robust as it could be.

But we need to rededicate ourselves to these kinds of tech programs that will support ultimately the technologies and ultimately protecting and helping the warfighter.

So, with that, thank you, Mr. Chairman. I yield back.

Mr. THORNBERRY. I thank the gentleman.

It looks like we have three votes. We have just about 9 minutes remaining in this vote. My guess is, that is probably going to mean 25 to 30 minutes, probably, before we are back.

You all make yourself as comfortable as you can. We will be back as soon as we can.

The hearing will be in recess.

[Recess.]

Mr. THORNBERRY. The subcommittee will come back to order. Thank you all for your patience.

And I will recognize the gentleman from Texas, Mr. Conaway, for 5 minutes.

Mr. CONAWAY. Thank you, Mr. Chairman.

And I appreciate everybody being here today.

Mr. Lemnios, I am told that you have devolved several of your projects out of your team on to the various services under the guise of efficiencies and possible cost-cutting to save dollars, and yet the requests in the programs don't seem to have been—the dollars still seem to be the same.

Can you walk us through how the mechanics on these efficiencies are going to work?

Secretary LEMNIOS. Congressman, absolutely. We, in fact, as part of the Secretary's efficiencies initiative, moved several projects from management out of the Office of the Secretary of Defense down to the services where those would be more impactful.

One of those is the work that we have with the historically black colleges and universities. That was devolved to the Army. In fact, the budget request is identical. The savings to the Department is the savings in, essentially, overhead, if we could call it that, and latency, latency of execution.

There were other projects, as well, across the Department that were moved to the services where they could be more efficiently executed without compromising the intent of those programs.

Mr. CONAWAY. Are you going to able to quantify that there are, in fact, savings? I mean, it is one thing to be intuitive about it, but it is something else if you can actually show where that has happened.

Secretary LEMNIOS. Well, I will tell you that the Secretary and, certainly, Dr. Carter is challenging us to quantify every one of the efficiencies——

Mr. CONAWAY. Okay.

Secretary LEMNIOS [continuing]. Transfers that we have had made. And we are in the middle of doing just that.

Mr. CONAWAY. A question for all of you in the time remaining.

The acquisitions panel that Rob Andrews and I worked on had extensive testimony that prototypes used earlier in the system would, in fact, save money and/or avoid cost overruns or cost—or challenges that happen by delaying that.

Have you been able to push prototyping further up, earlier into the food chain or the stream to any advantage, at this point?

And if any of you could answer.

Dr. FREEMAN. Yeah, let me take it first.

We actually are doing something, and, in our request, there is a $10 million increase in Army S&T. We have established a 6.4 funding line that I will manage out of Army S&T specifically to try to get competitive prototyping and taking technologies that are relatively immature, high-payoff-type technologies, and taking them to a higher technology readiness level.

And what this does is, we intend to increase this line over time, so this is sort of a beginning of that process of moving that prototyping earlier and earlier. And we are starting with $10 million. We are going to probably do a couple of programs this year, and then we will transition those over to acquisition programs. And

then we will increase that line over time, where we can do more and more of that kind of prototyping.

Mr. CONAWAY. Okay.

Admiral CARR. We have a similar initiative too, although the 6.4, at this point, has not been given directly over to me. I have been asked to put programs forward that would benefit from the application of 6.4; we call it speed to fleet.

About 30 percent of my budget is our Future Naval Capabilities, and these develop 5- to 7-year time horizon component technologies that go into programs of record. And so, aligning those prototypes with the program of record and making it so that the prototype can flow into the program of record with lower risk and lower cost, that is that lubrication we are looking for.

Mr. CONAWAY. Okay.

Admiral CARR. At a higher end, we have what we call our Innovative Naval Prototypes. These are the high-risk, high-payoff, like free-electron laser and electromagnetic railgun. These will deliver working prototypes that won't necessarily fall under a program of record but are disruptive technologies. So it is a slightly different application.

Mr. CONAWAY. Okay.

Dr. WALKER. Sir, part of our planning process I talked about was to generate these flagship capability concepts—these are large-scale, integrated demonstrations of technology—and connect those with development planning efforts to, as the admiral said, feed into programs of record the Air Force is thinking about.

So the three we picked this year all have development planning efforts and potential future programs of record that the Air Force is lining up. So the ability to connect S&T with the new program of record is what we are after.

Dr. DUGAN. We have a very aggressive manufacturing initiative at DARPA precisely to deal with some of the concerns that the Members here have raised.

The deputy director and I both come from private industry. We have both been engaged in the design, test, build, and fielding of original, new equipment. One of the things that we observed is that, every time we hit a seam in that process, when we go from design to prototype, from prototype to first production run, from first production run to full production run, every time we hit a seam, we encounter problems.

Now, when we examined the timeline to develop and field complex defense systems, we noted this increase from 2 years to 10 years. And then we sought existence proofs, essentially, of other industries where they weren't realizing that significant growth. And we observed them in the semiconductor industry, in software, and in pharmaceutical protein production.

And in each case, it is true that when you can improve the quality of your design tools such that you have a correct by construction type design, you improve the fluidity of your manufacture, you can begin to erase these seams. And it is with that very aggressive perspective that we are pursuing advances in manufacturing.

Mr. CONAWAY. All right.

Thank you, Mr. Chairman.

Mr. THORNBERRY. Thank you.

Mr. Gibson.

Mr. GIBSON. Thanks, Mr. Chairman.

I thank the panel for coming today. I appreciate your testimony and the tremendous work you are doing on behalf of all of our service men and women.

I have a series of questions. We will see how far we get on them. If not, I will submit them for the record.

The first has to do with brain injury and post-traumatic stress disorder. And I am interested to know the scope, where research is being done, and a summary of preliminary observations.

I guess I will point that toward Dr. Freeman and Admiral Carr, although I would be willing to hear from anybody that has anything on that score.

Dr. FREEMAN. Yeah, thank you for that question, because, you know, that is something that we are absolutely, positively working very, very hard on. And it is very frustrating for us as well as for the families and for the servicemembers themselves who are suffering, whether it is with traumatic brain injury or post-traumatic stress disorders, that we are trying to really understand that.

We are doing several things. We put a lot of money, a couple of years ago, into the medical research in this area. And what that did is that seeded a lot of research efforts, sort of, across the board to get that understanding of what is going on.

We are now in the process of taking that medical research and focusing it under several efforts and initiatives and under this soldier portfolio that I was talking about and pulling that research together to really make a huge difference. And a lot of that research is going on in universities, a lot of that research is going on in our medical centers.

And what we are trying to do, at this point—and I am sorry to say we don't have an answer today of, you know, being able to stop and/or totally treat and/or basically restore everybody's capability here, but we are working very hard across the board in both the medical and nonmedical areas to understand this problem. And we have a significant amount of our budget in the medical and in the nonmedical work to address that.

Admiral CARR. Thank you, also, for the question.

At the Naval Research Lab, right here down the river, we have done a lot of modeling on understanding the dynamics of traumatic brain injury, what goes on in the brain as it moves back and forth and overpressure. We have actually got mathematical models and physical models to try and understand that phenomenon better, and, from that, to try to understand a better helmet design, for example, how you might make sure the helmet is not part of the problem.

Mr. GIBSON. Yeah.

Admiral CARR. We are looking at additional technologies to try and inoculate the soldier or the Marine from that environment through training, through immersive training, multimode training, that can be very effective, as the Marines like to say, "so the first firefight is no worse than the last simulation"; and, finally, to find and identify markers that might give us insight into people that are at greater risk for suffering post-traumatic stress disorder.

And if I may just take a second and ask my deputy, General Hedelund, if he has anything to add about the training or the subject.

Mr. GIBSON. Thank you.

General HEDELUND. Thank you, sir.

Many of the Members may have visited the IIT [Infantry Immersion Trainer] facility out at Camp Pendleton. And, as the admiral mentioned, the technology that we are putting into that facility is aiding commanders, small-unit leaders, and individual Marines in getting exposed to what we are now beginning to call resiliency and to be able to make that a building block to a higher resiliency in our Marines.

Now, brain injury is brain injury. That is a topic, and we have heard already from the panel on how difficult that is. But the post-traumatic stress piece may be preventable, at least to a degree, by some of the resiliency work that we are doing. So the IIT helps us there, and there are a number of efforts in that realm.

Thank you.

Mr. GIBSON. I appreciate the updates, and it is encouraging. And I look forward to continuing to stay in touch with that as we go forward.

Dr. DUGAN. I can add to that, because we have had a role in TBI [traumatic brain injury] and also PTSD [post-traumatic stress disorder].

The TBI work was foundational for us. It characterized the levels of blast that would result in damage that could be recovered, damage that needed to be treated, and damage that was catastrophic. That work was then fed into our efforts to develop a low-cost blast dosimeter. They work hand-in-glove.

And both are part of an overall combat casualty care ethic at DARPA. We have six program managers devoted to combat casualty care. They have activities ranging from revolutionizing prosthetics all the way through to TBI.

Mr. GIBSON. Well, thank you very much. And I appreciate that.

Ms. Dugan, one last thing before I hand it back to the chairman. Have you been to the College of Nanoscale in Albany, New York, yet?

Dr. DUGAN. I have not personally been, no, sir.

Mr. GIBSON. Well, great. I would love to invite you on a trip. Some exciting research is going on up there, and I would like to introduce you to some of the folks up there, if you have time.

Dr. DUGAN. Thank you for your invitation.

Mr. GIBSON. And I yield back.

Mr. THORNBERRY. I thank the gentleman.

Mr. West.

Mr. WEST. Thank you, Mr. Chairman; also, Mr. Ranking Member.

Dr. Freeman, as a career Army combat arms officer, I am pretty aware that many of our ground-pounders have available to them an array of technologies that can greatly enhance their mission performance and probability of survivability. But they are unable to, you know, carry a lot of this stuff, as far as the full advantages of counter, sniper, IED [Improvised Explosive Device], UAV [Un-

manned Aerial Vehicle], and communications platforms, and other technologies.

I had some people talk to me about a platform out there, a system, and I would like to know, have you heard about this thing called the Jake? And if you have, can you tell me what stage we are in, as far as assessing the Jake? And if we see that it does have any merit, I mean, what is the way ahead, and, of course, how can this committee help you?

Dr. FREEMAN. Yeah, that is—what you refer to is obviously, you know, part of what we have rediscovered, as I said, about focusing on the soldier as the decisive weapon, and the idea that we have basically been adding things like ornaments on a Christmas tree to give them more capability, but also then we end up burdening them, both cognitively and physically, as well as protecting them.

And so we are really trying to understand—first of all, let me tell you that we are starting an effort that is—we put an additional $10 million in to study soldier load and to really get our arms around all of the things that can help us for soldiers and small units to balance that load and to get that load off of the soldier, to reduce it down to acceptable levels, as opposed to the 130 pounds that many folks carry today that you are well aware of.

I do know about the Jake mobility. The way I look at Jake is, it is an individual mobility-type platform. It falls, in my mind, into the arena of being a way to offload some of the weight because it can carry certain things that the soldier doesn't have to carry. But it also gets the soldier to the battle perhaps less fatigued.

Now, having said that, there are a number of different concepts like that out there. And what I have offered to do and we are pursuing this year and I am trying to get it done in the springtime here, maybe June-type timeframe, is do what we call a mobility war game, where we are going to bring people from across the Army together with, first of all, soldiers who have experience. We are going to have a vignette that we play or a scenario that we play that is really looking at how the small combat units would use equipment like Jake and other kinds of mobility or offloading-type technologies. We then compare the results of these tabletop war games and try to figure out, you know, okay, what did the soldiers like about it, what didn't they like about it, how successful was it.

Depending on the outcome of that game, then we can figure out where we want to go, if we want to go with Jake or any of these other kinds of systems.

Mr. WEST. Thank you.

And one other question I had: Last week, the AUSA [Association of the United States Army] went to a symposium that was down in our district in south Florida. And one of the—dovetailing off of what Representative Gibson talked about—BAE Systems has a helmet out there which has a brain sensor in it which can help with the evaluative protocols in near-time.

Are we looking to see how we can develop that helmet system?

Dr. FREEMAN. Yes, actually, Representative, we really have been working that. In fact, I have been working ever since I was up at Natick. We had a CRADA [cooperative research and development agreement] with BAE. And BAE has been looking on their IR&D [industrial research and development], by the way, at these kinds

of load and different equipment that will help unburden the soldier. And they did look at and we have looked at their helmet design.

We are taking those kinds of things—because there are a number of helmet designs. We are working with the Natick folks, and we are working with the medical folks, as well as the PEO [Program Executive Office], to look at new helmet designs. And that will be included in how we look at where we are going. This would be beyond ACH [Advanced Combat Helmet].

Mr. WEST. Well, thank you very much, panel.

And I yield back to the chairman.

Mr. THORNBERRY. I thank the gentleman.

Ms. Sanchez.

Ms. SANCHEZ. Thank you, Chairman.

And thank you, again, to all of you. And I just want to reiterate how proud we are of you and your work and service to our United States. I have had the pleasure of working with several of you personally, and you are top-notch people.

I have a couple of questions that I want, one that is very specific to a particular program that I have for the panel, and then the second would be about our labs. As you know, we have several great ones in California.

The first one is about the Medical Free Electron Laser program. And it is peer-reviewed. It is competitive grant funding. And in partnership with the military's medical laboratories, centers selected for funding under this program have had an impressive record of technology innovation and invention.

The Department has judged this program as being important to meeting the joint force's health protection capability gaps requiring medical R&D in the Department's assessment report, "Guidance for Development of the Force, Fiscal Years 2010–2015."

So in fiscal year 2010, the Military Photomedicine Program was placed under the wing of the Defense Health Program, DHP, and was funded with an allocation of $5 million from the GDF [Guidance for the Development of the Force] enhancement funding. But in the fiscal year 2012, the President's request has cut that line item by $125 million less than the program before, which means that this Military Photomedicine Program is a program that is well-liked, has great results, but there doesn't seem to be any funding for it in the fiscal year 2012 budget.

So I would like to know specifically what your ideas are on where the funding is going to come to continue to do that program.

Sorry for getting technical, but I think you know where I am headed.

Dr. FREEMAN. I will take that one on.

The fact is that, you know, that is a program that I have very little familiarity with in specifics. What I would like to do is, I would like to take that for the record and get an answer back to you.

[The information referred to can be found in the Appendix on page 145.]

Dr. FREEMAN. Because I really need to go to work with the commander of the MRMC, Medical Research and Materiel Command, and get an answer to that. Because that would be under his realm

of responsibility, and he has authority over that DHP program, where I do not. But we work together very closely, and I will get an answer for you.

Ms. SANCHEZ. Great. Well, obviously, some of my funding in my district is directly—you know, they keep changing where they get the money from, and they don't know. And, as you know, stability and understanding where moneys are coming from, or if they are even coming, is important, as these technically very professional people, just as you would, you know, put their lives on hold to go and do something for the government, and they don't know if they are going to have a job tomorrow. So it is about jobs, jobs, jobs.

Okay, the other question that I have is about facilities. I think that this committee has invested a lot in the people between the walls. I mean, we have been working very hard and we have put the money in. But I am very concerned about this new technology innovation/creation that you all are in charge of sitting in outdated labs or labs of the 20th century, if you will.

And how can we help you? And do you need help in that arena?

Secretary LEMNIOS. Well, Congresswoman Sanchez, let me start, and, certainly, the service S&T executives can respond specifically with regard to their service.

Having come from a federally funded research and development center and having worked in a building that was built the same date as the Pentagon was built, I know the issues very well. We had a facility at MIT [Massachusetts Institute of Technology] that was absolutely first-rate because of its people, because of its mission, but, in fact, we had facilities that were 50 years old or even older. And that wasn't part of any budget authority that would allow us to update those. And that is really your question, how do we do that.

I will simply point out that there are three things that we need in our laboratories. We have two of them. The first is a mission, a clear direction in terms of what problem are the laboratories addressing that has significance to our Nation and to our Department. We have that.

The second is first-rate people. And I have visited many of the laboratories. In fact, we have absolutely first-rate people. But if we don't have the facilities, that third piece just isn't there, and that is really a cohesive piece.

As I have visited the Air Force Research Laboratory in Dayton, as I have visited the Naval Research Laboratory not too far from here, certainly Aberdeen and other facilities are a big issue, and that is an authority that we probably need your help with.

The services can talk specifically to their areas, but I will simply say that, as we have looked across the S&T enterprise, the science and technology enterprise, we have been clear about what our S&T priorities are. And that provides us a challenge to work with the laboratories to really make sure we fit those laboratories with the resources they need to work in those areas.

I think it is going to look very different 5, 10 years from now as compared with today. The commercial sector's laboratories look very different today as they did 10 years ago. So I don't think it is just a matter of rebuilding the bricks and mortar that we have in place today, and I don't think it is even quite the same footprint.

I am not sure what the footprint actually looks like. And I think we really need to go back and look at that in light of how the commercial sector does their basic research, how academia does its, and how the Department should do our basic research efforts.

Ms. SANCHEZ. I saw that you gaveled me, so—I mean, I would love to hear anybody else's response if they have a particular request of this committee to push. Mr. Chairman?

Mr. THORNBERRY. If there is a brief additional response, since we have fewer Members than before.

Admiral CARR. I would just add that the Naval Research Lab was authorized and appropriated in 1916, and some of the buildings look like it. We do our best to try and keep up with facilities modernization, but, particularly in a day like this, it is just very difficult for labs and shore infrastructure to compete with piers and runways and the other kinds of infrastructure that directly support the mission.

So it is a real challenge for us. We are trying to modernize what we have. We do have one MILCON [Military Construction] in progress right now; it is an autonomy lab at NRL [the Naval Research Lab]. But MILCON, in particular, is very difficult.

And I would just like to add, thank you. You are absolutely right. The support for the people programs that the committee has put in place have been very, very helpful. Because part of the challenge isn't just the facilities but, as you said, hanging on to the people that have to work in those buildings, and they look around at other opportunities. So some of the other inducements and flexibilities that the committee has given us to do that are very helpful. Thank you.

Dr. WALKER. I would just add that AFRL [the Air Force Research Laboratory] is not in bad shape because we have the 2005 BRAC. And so, a lot of that movement has come with money to build buildings. Section 219 has also helped us build new laboratory space, and so that has been very helpful.

Dr. FREEMAN. And just add, for the Army, you know, BRAC is helping us, with Aberdeen in particular. But all of the other laboratories have serious issues. And what I am looking at is taking a look at it across the board. Instead of them being lab directors leaving them to just look at their problem on their own or in their command, I want to take that up to a higher level and work to try to figure out what our priorities should be across the laboratories in the Army. And then I look forward to working with you all to figure out what kind of authorities we can have to use funding to solve those problems.

Dr. DUGAN. And I will just add, so as not to be noticeably absent, we have no captive labs at DARPA. And we rely on the health of the laboratories in the service organizations as part of our performer base.

Ms. SANCHEZ. Thank you.

Thank you, Mr. Chairman.

Mr. THORNBERRY. I appreciate the gentlelady raising the issue. I think it is interesting, and it is something that we can also keep our eye on, as we serve on more than one subcommittee, and try to work it out.

Let me ask about a few things.

Mr. Secretary, as I am listening to Members ask you all a wide variety of questions, the question occurs to me about setting priorities within this wide portfolio.

The intelligence community has a priorities framework, kind of a matrix on what is more important for collection purposes and what is less important for collection purposes, to help prioritize. When somebody comes up with a suggestion, you see where it is on the matrix and how high a priority it may be.

Is there something like that that you use or that the S&T community uses to help prioritize where money goes?

Secretary LEMNIOS. Chairman, let me start by outlining the very first priority, and that is support to our troops in harm's way. And there is no ambiguity there at all. We look to our joint urgent operational needs. We hear directly from the combatant commanders. We visit theater. We have a direct signal from those in-theater to give us a clear indication of what is needed.

And that is absolutely the first set of topics that we address. Dr. Dugan has spoken of that. My co-panelists have, as well. We have all had the opportunity to engage in that discussion and engage in those deliveries. That is job one.

Beyond that, we have a responsibility to set the long-term future for the Department and for the Nation, make those bets in people and ideas. And, again, I will point to DARPA as one example. The service laboratories are another example of places where we make investments in people and ideas to serve our Nation's future.

In that second case, in sort of the S&T piece, we have worked collectively over the past 6 or so months to identify our science and technology priorities. Those are in my testimony. And we have done that by looking at the future mission needs of the Department, taking those mission needs, creating a set of architectures; from each of those architectures, outlining what are the critical capabilities that we need as a department; and for each of those critical capabilities, what are the foundational technologies that support those needs.

That allows us, then, to have a discussion with industry, with academia, and certainly with the services in terms of how we will transition those concepts.

Now, that is an ongoing thing. There are clearly near-term needs that we are addressing, but we have to have the ability to make bets with high risk that have enormous payoff, and we are doing that across the board. Roughly 10 percent of our budget is in that very high-risk area, where not all those bets will pay off, but the ones that do will have a big impact. And I think you have seen examples of each of those.

Mr. THORNBERRY. But it would be too difficult, I take it, to put a number, a metric, on kind of those longer-range bets that are not the immediate warfighter needs.

Secretary LEMNIOS. I have had a challenge when people ask me, what is the return on investment on your S&T, your long-term bets. We have all been in that discussion. I don't know what the ROI was when Steve Jobs first proposed the iPad, but I know what it is now for that corporation.

Mr. THORNBERRY. Yeah. I am not really thinking of return on investment. I am thinking of the priorities or the problems you face.

And that is an arbitrary number. I mean, that is the way it works in the intelligence community. It is an arbitrary number about the nature of the threats, but, still, they get a number assigned to them. And you can argue right or wrong, but it just helps—and that is why it occurs to me. Because it just seems to me a massive—a very difficult job.

Secretary LEMNIOS. Let me just make one last comment to that.

Mr. THORNBERRY. Sure.

Secretary LEMNIOS. There are, sort of, two ways that we are doing this.

One is, sort of, across the Department we have identified a set of science and technology priorities. There are seven of those. And we are tracking progress in each of those. We are roadmapping the technical progress, where we see the performer base and where we see transition of those ideas to theater and to the capabilities set.

But we also have, beyond that, the services and certainly DARPA, as the engine of innovation, challenging that thinking. And we should challenge that thinking. There are ideas that we have that are part of the mainstream that we clearly have to implement, but we need a channel that, sort of, disrupts all of that.

And that starts with the computational framework that Dr. Dugan talked about. It then goes toward a discussion with the services and with industry in terms of what those ideas are. And it reaches into our academic environment to really challenge the disciplines and the training that we have for future leaders in that S&T community.

So I think we are actually doing that. The challenge is, it is not a simple, bounded problem. And the interesting problems are the ones that, in fact, aren't simple and bounded. And we are in that space in many ways.

Mr. THORNBERRY. Well, and I think, from my point of view at least, we want to encourage you to take some of those long bets, and we want to encourage that unconventional thinking and approach that comes. That is very important.

I have a number of other questions, but let me yield to other Members.

The gentleman from Rhode Island.

Mr. LANGEVIN. Thank you, Mr. Chairman.

As we noted in our first subcommittee hearing only just 2 weeks ago, cybersecurity is quickly becoming a major challenge for our military and our Nation.

Dr. Dugan, you and I have spoken about this in my office. And, certainly, I appreciated your comments in your opening statement about our efforts to stop cyber attacks, which are divergent from the threat and are taking us on a path of spending that is unsustainable in the long term. And, obviously, this challenge requires a new way of thinking about cybersecurity and learning to look at risks to our government.

So I would like to begin with you, Dr. Dugan, if I could, but then open up the question to our panel, and ask, what work is being done to change how we think about cybersecurity? And what is being done to better identify and mitigate our risks?

And if I could—and then I will have another question, if I could, on some other issues. But let's start with that, if I could.

Dr. DUGAN. Okay. So I would like to describe three programs that I think characterize how far we are reaching with respect to our cyber activities. The first is a program named PROCEED.

About 1½ years ago, a researcher named Craig Gentry produced what we call a theoretical construction for fully homomorphic encryption. Now, what does that mean? Homomorphic encryption is the ability to compute on encrypted data without decrypting it.

Now, were we to be successful in this, it would tremendously change the risk profile of how we conduct computations in areas where we have untrusted systems or systems of unknown provenance. That is the good news; we have a theoretical construction. The bad news is that it is not yet practical.

So, in the first instantiation of fully homomorphic encryption, researchers performed a simple "and" function. And that simple "and" function took about 30 minutes. Using conventional systems, that same function would take a fraction of a nanosecond. So we are 14 orders of magnitude away in terms of our speed.

The PROCEED program at DARPA is devoted to changing that timeline. It is a very big reach, from a research perspective.

Another example is a program called CRASH, which seeks to develop cybersecurity technologies that rethink the basic hardware and software designs. It is modeled after the human immune system, which has two components: an innate system, which is fast and deadly against a series of known pathogens; and an adaptive system, which is slower and recognizes novel pathogens. The result for us as humans is resiliency and survivability as a species.

And if we are able to achieve comparable types of effects in computer designs, then we can radically change this attack profile for the adversary. Essentially, what we are doing then is flipping the asymmetry by making each computer look a little different, just as our immune systems are a little different, and therefore much more difficult to attack. What we are doing under CRASH is trying to create survival of the cyber species.

The last example I would like to leave you with is a program called CINDER, which is focused on the insider threat. It is based on a mission profile rather than the detection of a series of events, single intrusion detections. The idea there is that, when an insider means harm to a system, they conduct a series of events that are strung together in a mission, and that, by looking for those mission profiles, we might better be able to detect them with a lower false alarm.

Our overall cyber program is 100 percent increased over fiscal year 2011. And, as many of you know, we have additional funds coming in through the budget request over the FYDP to the tune of about $500 million, starting with $50 million and increasing $25 million each year thereafter.

We have recruited an expert team. They come from the "white hat" hacker community, they come from industry, they come from a variety of sources. And we are serious about the big reach for us in cyber.

Mr. LANGEVIN. Very good. Thank you, Dr. Dugan.

Others, comment on this issue?

Secretary LEMNIOS. Let me extend Dr. Dugan's comments.

From a Department perspective, one of the seven S&T priority areas is, in fact, the cyber science and technology. It is one that we recognized and we tied directly to the existing and the future missions of the Department. In fact, that is a key element of the architectures that we have done the analysis on.

Over the FYDP, in the President's budget request fiscal year 2012 and out, that is about a $1.6 billion investment request in 6.1 through 6.3. So it is not small.

But the real issue is, where are the ideas and where are the people, and how do we test those ideas? And so, a good part of our work currently is to look broadly at, what are the architectural constructs? How do we think about how do we evaluate and test the insider threat, which is the most vicious of all? And how would we transition those concepts to operational use?

I will tell you that, in the last six months, I have been out at Pacific Command—in fact, I will be there this weekend—for testing that is going on right there in a testbed that they have put in place to not only test new concepts but understand how those concepts apply to Pacific Fleet and to the operational command, how would we actually use these concepts to protect our networks and our communication portals in real-time.

Access to testbeds like that that allow the contractor community to see real data and to work in a combatant commander's environment without compromising the operational needs but working real-time with a user to evaluate new concepts is absolutely critical.

So, in fact, there is an architectural piece to this that is absolutely important. There is the disruptive piece that is being funded out of DARPA that is absolutely essential. And then there is, how do we protect the existing networks and existing concepts that we have in place.

Secretary Lynn, in fact, in his *Foreign Affairs* article late last year, outlined a five-tier strategy for that, and I would point you in that direction.

But this is a place where the Department's investments in science and technology we have ramped up. The budget request is certainly reflective of that. And that is something that has to be in place over the next several years.

Admiral CARR. Cyber is a high priority for all the services, of course. I would just add that, in the Navy, we are careful not to take it in isolation. We have to consider it in the context of the other dimensions of warfare. We really can't think just about having a cyber game or a cyber solution; how do we fight across the dimensions of kinetic, hyperspectral, and cyber.

We have recently stood up—the CNO [Chief of Naval Operations] has designated a deputy CNO for information dominance, Admiral Dorsett. And we have stood up the 10th Fleet. Those are our primary customers for resources, requirements, and operations.

And I would just add that, when it comes to the epidemiological model, there may be some application there, of course, but you have to remember these are like bugs that have brains. They are thinking adversaries. So they are not just bacteria. And so, we are working on how maybe better to model that, working with some FFRDCs [Federally Funded Research and Development Centers].

And there is some particularly good capability up at Carnegie-Mellon, has been very forward-leaning.

Dr. WALKER. On the Air Force S&T side, we are looking at something we call cyber agility, which is having the network or the system of networks move, not being at an IP [internet protocol] address longer than a fraction of a second, so it is very hard for the attacker to find out where you are.

We are also working cybersecurity issues for cloud computing, as we move into that world. You know, how do we secure our data in the cloud.

And I will just mention, many of our projects are joint with DARPA up at Rome, New York, where our AFRL information directorate is located.

Dr. FREEMAN. And, you know, I came out—one of my previous lives, I worked in the old nuclear community. And one of the things that we did when we were working in that community was, if you designed something, you also did what we called the countermeasures and then the counter-countermeasures and then the counter-counter-countermeasures, which was, you figured out in the design what you needed to do in order to be ahead of whoever was going to be tampering with whatever it was that you were designing.

And one of the things that I am trying to do is, as we look at our C3 [command, control, and communications] portfolio, I am going to be challenging our science and engineers to do a lot more of that kind of thinking, as opposed to just designing things and then, you know, kind of saying, "Okay, here it is," and then let somebody else go figure out and not know how easy or difficult it might be to attack.

Mr. LANGEVIN. Very good.

I want to thank you all for your input on this topic. Obviously, it is a growing challenge to our national security. And the cyber threat obviously is, as you well recognize and we talked about, is an evolving threat. It is very challenging to stay one step ahead of the bad guys. I am glad to hear that you are all thinking outside the box, which is exactly what we expect you will do. And it sounds like you are on some very interesting work. And I look forward to continuing to monitor it and to work with you on the subject.

With that, thank you, Mr. Chairman. I yield back. I will have some other questions for the record, by the way, but time constraints.

Mr. THORNBERRY. I thank the gentleman, and I appreciate his questions.

Mr. Gibson, do you have other questions?

Mr. GIBSON. Yeah, thanks, Mr. Chairman.

For Admiral Carr, is the Navy doing anything on research for nuclear reprocessing?

Admiral CARR. The Navy's organization that handles all things nuclear is NAVSEA 08, under a four-star admiral who is double-hatted in the Department of Energy. So it is a very old, tried, trusted structure. So we don't touch things nuclear, with the exception of looking at peripheral technologies that might help.

So the short answer is, no, sir. We are not doing anything in that area.

Mr. GIBSON. How about for anybody on the panel on that?

Okay, thanks.

I yield back.

Mr. THORNBERRY. Ms. Sanchez, do you have other questions?

Mr. West.

Mr. WEST. Yes, I just had one other follow-up question.

Last week, I had the opportunity to go down and get an ops intel briefing from U.S. Southern Command. And one of the things, when we talk about emerging threats, are these mini-submersibles that are very, very hard to detect.

And are we looking at, you know, new technologies to understand who may be developing these and how we come up with countermeasures as far as tracking them? Because right now, the ISR [intelligence, surveillance, and reconnaissance] platforms we have, you know, it is very difficult for them to track these systems.

Thank you.

Secretary LEMNIOS. Congressman, we have been following that activity from the semi-submersibles to the recent incident about 2 weeks ago. We have a program through our Rapid Reaction Technology Office that has both evaluated the threat, has postulated where that might go, and is starting to put in place, I will just say, concepts to track future threats.

We have worked closely—I have been down at SOCOM [Special Operations Command] twice. I have been down at JIATF [Joint Interagency Task Force]–South twice and, in fact, worked with the commander there to understand what the future of that AOR [area of responsibility] looks like.

We have put in place, in fact, a test campaign that started two years ago in Key West—and we have now done two of these—to both collect littoral data and share that with the contractor community to build detection schemes and discrimination schemes to allow us to more rapidly detect threats like that.

So we are absolutely on top of that. In fact, not only at SOCOM, but—not only at SOUTHCOM [United States Southern Command], but also as part of JIATF–South and SOCOM, we are exploring that.

Mr. WEST. Thank you very much, sir.

And, Mr. Chairman, I yield back.

Mr. THORNBERRY. Thank you.

Mr. Gibson's question raises a question in my mind. This morning, we had Secretary of the Navy, CNO in front of the full committee; lots of questions about alternative energy sources and so forth.

Mr. Secretary, using that as an example, I am sure all of the services, and certainly DARPA, are doing research into alternative energy, because of its obvious importance that we all know. How do you coordinate something like that?

Because it would seem to me, the temptation would be for everybody to be pursuing these various alternatives, but, yet, you know, part of the sensitivity—story today about how many duplicative Federal programs there are in a whole variety of domestic areas.

It is good to have competing ideas pursuing research, and yet the budget that we face—so you understand the gives and takes here that we are, kind of, looking at. And so, using energy as an exam-

ple, how do you figure out what is duplicative, what is needed, and so forth?

Secretary LEMNIOS. Chairman, let me echo, as well, that duplicative research is actually not a bad thing. Competing research is actually a very good thing, because it challenges our thinking.

Duplicative procurement is something quite different. So, on the S&T piece, getting competing concepts on the table in a fair-game exchange in a shootout for what works and what doesn't and understanding what that trade space is is the game that you see in front of you. And we are in that space, in many areas.

It is interesting that the energy issue came up this morning. In fact, I was at ARPA–E [Advanced Research Projects Agency–Energy] yesterday giving a talk. And Secretary Mabus will be there on Wednesday announcing a collaboration that the Department of Defense and the Department of Energy has to develop concepts really across the board.

I would sort of answer the question, though, in terms of how do we structure our investments in two areas. There are S&T concepts that are sort of unitary concepts, and we have a number of those that you have seen. Many of those have paid great dividends, and they are starting to find their way into the acquisition system. Batteries are just one example. High-efficiency solar cells are yet another example—a terrific opportunity for the private sector to actually drive in an area where the Department needs that capability.

But there is, in fact, a much bigger issue, and that is the system implementation of how do we go from storage to use and really the full concept of how we would implement an energy-efficient, end-to-end solution.

Much of the alternative fuel program is now centered not so much on the ideas but on getting the price down of a producible alternative fuel system that could be brought to market. In fact, those programs are pretty far along. They are very far along technically, but it is now the issue of how do we build a business case and work with the private sector to commercialize the early S&T concepts.

So I think you are seeing lots of cases where the Department has recognized the need for alternative fuels and reduction in power and energy storage to meet our needs. Ground combat vehicles are a great example of this. The Navy's fleets are another good example of this. And it goes on and on. But, at this point, it really is sort of driving the cost down from first use to implementation.

Admiral CARR. I would just add, very quickly, that we do collaborate, and particularly with the Air Force and working with aircraft technologies to get fuel efficiency up. We are collaborating on the development of an engine that is a high/low bypass engine. It used to be, you could either go supersonic efficiently or slow like an airliner efficiently. We would like to develop an engine that does both. Higher temperature, of course, means more efficiency, so we are collaborating on some turbine blade coatings and development.

There are things that are uniquely naval. Particularly, underwater UUV [unmanned underwater vehicle] technology is sort of a niche. But I think we try hard to collaborate where it makes sense and look within for those special niches where we have them.

For Marines, power and energy just means make me lighter; give me juice, but don't make me carry so much weight—lighter batteries, photovoltaics, things that will generate power. And you can recover energy just from walking.

So I think we are a little unique because we have aircraft, ground-pounders, and ships and vehicles.

Mr. THORNBERRY. Okay. Good.

Dr. Dugan, let me ask this, with Mr. Langevin's questions on cyber, and you talked about several of the initiatives that DARPA has in cyber. I suspect that Dell and HP [Hewlett-Packard] are also working, kind of, next-generation computing that could be more secure because that would be a product that they could sell.

My question is, in making your decisions on which products to pursue, how do you factor in what private industry is doing on its own and ensure that you are supplemental rather than something that in some way distorts the market or replaces what they are doing on their own?

Dr. DUGAN. Yeah, it is a very good question. I would tell you that the program managers at DARPA are experts in their field. They are very often very closely coupled with their colleagues and experts in private industry and in other—and in academe, as an example.

The clean-slate initiatives that we are investigating are perhaps the ones that touch most closely on your question. So the traditional impediment for investigating clean-slate initiatives, new designs, whole new designs for operating systems or computing systems, is often limited by challenges against the feasibility of employing them economically.

So one of the things that we began to look at is exactly the opportunity for insertion for new technology, such as clean-slate design as articulated under CRASH. And what we observed is that, by 2012, the purchase of smart phones, as an example, will exceed the purchase of laptop and desktop computers combined. Therein lies an opportunity to insert new technology that is consistent with the business models and the economic aims of many of those in private industry.

We are actively engaged with them. They are part of our research projects. And so I feel that that close coupling is healthy at DARPA.

Mr. THORNBERRY. Mr. Secretary, let me broaden the question a little bit. How do you maintain visibility in what the private sector is doing, in order to integrate not only across those of you who are there but into those efforts?

Secretary LEMNIOS. Well, first of all, many of us came from the private sector and we have a remarkable Rolodex. The hours and the salary changed, but the Rolodex didn't. And so, in fact, it is critically important that we maintain that coupling.

I think you would find, every one of us spends a lot of time engaging with industry, whether it is conferences, whether it is on a study panel. I know that in cyber, for example, early last year when we wanted to sort of get ground truth of what was happening in the private sector, we brought people in. We convened a study that included leading universities and leading companies to come in and tell us, what are your leading ideas that you are supporting?

So it really is a full-time engagement. And this is really across our—I would echo Dr. Dugan's point that her program managers are best in class. We pull them from industry. After a few years, you send them back, and they have made a great contribution to the Nation.

Mr. THORNBERRY. What effect, if any, does the lack of a long-term reauthorization on the Small Business Innovative Research Program have on your ability to do strategic planning and integration of those efforts into core S&T programs?

Secretary LEMNIOS. Chairman, let me start with that. As you and I have talked, that is a particular concern of ours, of mine. We deal with the small-business community all the time.

And I will give you one specific example. There is a program that we are funding in the LA [Los Angeles] area to build an airship, and we are working with a small company, and we are simply metering out payments to this company. It is a 30-member company, and they are sort of hanging by a thread. So we can't do long-range planning without a budget in place, and it puts those companies at risk.

The same was true with a small company that I saw on the eastern shore of Maryland that is building force protection equipment for our troops. It is simply a matter of scaling it out. It is like building a house, and instead of building it on the cost and architect's budget and timeline that you would like, you sort of stretch it out, and it is going to cost more.

So there is an unpaid bill that is a result of this, and it is adding enormous risk to our small-business community.

Mr. THORNBERRY. Dr. Freeman, this may not be fair, but I have the idea that a lot of medical research that is done at the Department of Defense has a tenuous connection to the warfighter or even our service people. A lot of it has been foisted upon the Department by Congress.

Now, I don't know if that is—but it does occur to me that, as budgets tighten and as we have these extremely serious, urgent issues like Mr. Gibson was asking about, that we might have to adjust our priorities a little bit. And some of these things in the field of medical research that the Department has been doing may need to take a lower priority.

Do you have any comment about that?

Dr. FREEMAN. You bring up a tremendously important issue for us, you know, and it has several aspects, right? I mean, one of them is the Medical Research Command has gotten a tremendous amount of adds over the years, earmarks over the years. And, in fact, they had to stand up—in order to handle the very large volume of those, they had to stand up an organization basically to handle all of that.

And, of course, we have some issues as we remain on a continuing resolution, if we do, that basically, you know, in 2011 we are okay because we are continuing to operate those particular programs and execute those programs from past adds. However, as we move to 2012, we are going to have to seriously consider what we do there.

So one of them is the infrastructure that that has caused in our medical community, and so we have to deal with that. But we are dealing with that, and the commander and I are dealing with that.

The second issue that you bring, however, is the, you know, what I would call, kind of, just a huge smattering of a variety of topics that have been funded over time, some in the program but mostly in the non-core budget. And I have mixed feelings about those. I really do.

The first thing is that, you know, a lot of those things that don't seem, maybe, on the surface to be really, really beneficial to our service men and women actually are. Breast cancer is a huge issue for not only the women of this country—I am a breast cancer survivor, so I am very glad all that research was there—but also for our females in the military. And so, you know, even though that may not have been intended entirely for the military, it has had a great benefit, as have many of those kinds of efforts.

On the other hand, you are absolutely right. We are going to have to tighten our belt, take a look—and you mentioned the word "priorities." I mentioned the word "priorities" in my testimony. And I think we are going to have to look at that, and we are going to have to look at that hard.

What I will tell you is that we do have to maintain a very broad look at all of the different kinds of medical research that need to be done. And so, as we look at what we are doing, we have to look in many different ways. We have to look at treatment, we have to look at prevention, we have to look at vaccines. We have to look at an awful lot of those things which do really help our service men and women. Some of those historic things will go away, as we take a hard look at those things. Some of those things we will have to continue.

One of the big issues that we have by not being able to move things out of the medical research in a very fast manner is the approval process for drugs and so on and so forth, which, of course, stymies an awful lot of—as we go through—and we want to be sure we are absolutely doing the right thing, but that takes it a long time to get the things that can be beneficial out to our warfighters.

So I think you bring up a really good point, and I would love to discuss it further with you.

Mr. THORNBERRY. Well, I guess—yeah. I would, too. And I appreciate the points you make, but we can't duplicate NIH [the National Institutes of Health] at DOD, so—I appreciate it.

Dr. Walker, you mentioned in your statement some upgrade, kind of, research on missiles and so forth. I am thinking about our strategic triad and so forth. Do you all have anything going on, though, as far as—and maybe this would not be S&T in these accounts—but as far as replacements?

What sort of work is the Air Force doing as far as missile technology goes? You look around the world, and there are lots of missiles that a lot of people have. Are we doing the kind of research we need to understand that and possibly have our own improved systems if we choose to?

Dr. WALKER. Great question. We are heavily invested in the Air Force S&T Program in propulsion and guidance technologies for Minuteman III-type replacement strategic systems. We, in par-

ticular, are looking at advanced inertial measurement unit guidance packages for denied GPS environments and applying those to strategic systems, as well as looking at solid propellant S&T work out at our Edwards facility to, among other things, maintain that industrial base that is so critical to the Nation and look at next-generation-type ICBM [intercontinental ballistic missile] systems.

It is interesting you ask the question. I came from DARPA, actually, as well. And DARPA and the Air Force are working a program looking at conventional strategic systems, a technology program. And the Air Force piece of that is looking at the DARPA design for that boost-glide vehicle system and looking at how we would use that to strike targets from a strategic standpoint. So, actually, we are tied at the hip on that program.

And, you know, conventional strike, at this point, it is a technology look, but it is important, I think, for future options in our strategic systems.

Thank you.

Mr. THORNBERRY. I think so, too. I think it is important to have future options beyond our current system.

Mr. Langevin, do you have other questions?

Mr. LANGEVIN. No, thank you.

Mr. THORNBERRY. Mr. Gibson, do you have other questions?

Mr. GIBSON. No.

Mr. THORNBERRY. Well, I think you all wore us out.

I suspect there will be other questions that we would submit for the record.

But, again, I appreciate each of you being here today. I appreciate your patience while we had votes, and appreciate the work that you and your organizations do.

With that, the hearing stands adjourned.

[Whereupon, at 5:25 p.m., the subcommittee was adjourned.]

A P P E N D I X

March 1, 2011

PREPARED STATEMENTS SUBMITTED FOR THE RECORD

MARCH 1, 2011

Opening Statement of
Congressman James R. Langevin
Emerging Threats and Capabilities Subcommittee Hearing
DOD Science and Technology Programs for FY2012

March 1, 2011

Thank you, Mr. Chairman, and thanks to all of our witnesses. I firmly believe that the continued strength of our nation is reliant upon our ability to continue to lead the world in innovation and advanced research and development.

From GPS to the Internet, we are all aware of the benefits that investments in Defense Science and Technology have had on our daily lives, but what is sometimes overlooked is the remarkable impact these programs have on our national economic and educational competitiveness.

The goal of these programs is to invest in emerging science that will become the backbone of tomorrow's fighting force. To do this, however, the United States must maintain a strong research and development capability housed inside and outside of government by partnering with industry and academia.

For example, 60 percent of the Department's basic research investment, $1.2 billion, goes directly to local universities to promote projects advancing knowledge and understanding across a wide array of fields, from advanced mathematics to environmental sciences.

These programs not only have a vital national security benefit, but are a critical source of funding to keep the U.S. leading the world in academic research and development. Similarly, the Department devotes the majority of its remaining science and technology budget to support defense laboratories and industry research efforts.

While much of these funds goes to support larger contractors and corporations, the Department also makes targeted investments in small businesses that specialize in specific high technology research and development efforts.

These smaller partners provide critical technology that is often too narrow and highly specialized for larger companies to consider. Because of their size, small high tech companies can often complete specific research and development projects faster and more efficiently than larger contractors positioned to handle major, large scale programs.

These small businesses are excellent tools in achieving great efficiencies in the Department's Science and Technology efforts and I commend the Department for recognizing their importance.

I have been troubled, however, that our efforts in Congress to authorize initiatives like Small Business Innovation Research (SBIR) and the Mentor-Protégé Program have fallen by the wayside. With that in mind, I hope that our panel will address specific efforts to increase outreach and partner with academia and small businesses. Thank you once again and I look forward to your opening statements.

Statement Testimony of

The Honorable Zachary J. Lemnios
Assistant Secretary of Defense for Research and Engineering (ASD(R&E))

Before the United States House of Representatives
Committee on Armed Services
Subcommittee on Emerging Threats and Capabilities

March 1, 2011

Mr. Chairman, Ranking Member Langevin, members of the committee, I am pleased to be here today on behalf of the dedicated men and women of the Department of Defense, who discover, develop, engineer, and field the critical technologies for our deployed troops and who are laying the foundation for a secure future. I would like to thank the members of Congress for your continued support of the Department's science and technology (S&T) program and our broader research and engineering (R&E) program[1]. Your steadfast support has allowed the Department to field technologically-based military capabilities that are unmatched anywhere in the world and provide the capability edge upon which our Soldiers, Sailors, Airmen and Marines rely.

I am also honored to be joined today by leaders of the Department's S&T organizations who will provide testimony in support of their individual S&T efforts: Dr. Marilyn Freeman from the Army, Rear Admiral Nevin Carr from the Navy, Dr. Steven Walker from the Air Force, and Dr. Regina Dugan from the Defense Advanced Research Projects Agency (DARPA). Their leadership of the DoD S&T community is critical to the ability of our forces to meet today's challenges and to prepare for the future. This team has worked closely over the past six months as part of the S&T leadership panel - the DoD Science and Technology Executive Committee (S&T EXCOM) - to ensure the Department's S&T investments are responsive to current and future warfighter needs. Together, we are keenly aware of the budget pressures facing the Nation and have made a collective commitment to ensure that the taxpayers' dollars provided to the Department's S&T enterprise are used wisely and efficiently.

FY 2011 Continuing Resolution Crisis

During the 17 February 2011 Congressional Budget hearings on the FY 2012 Defense Budget, Secretary of Defense Robert Gates said, "I want to start by making it clear that the Department of Defense will face a crisis if we end up with a year-long continuing resolution or a significant funding cut for FY 2011." This crisis would extend to the science and technology community. While much of the S&T program is planned and executed in a structured manner, the realities of a rapidly evolving and adaptable adversary in Afghanistan mean that we must conduct new starts in programs like the Joint Capability Technology Demonstration (JCTD) in a timely manner. We must also be able to reprogram available funds for higher priority needs. Operating under a year-long continuing resolution or with substantial reductions to the President's FY 2011 Budget request would allow neither, and would result in the loss of tools the Department needs to more rapidly adapt to emerging threats. One example is the delay in planned research efforts of the Systems Engineering Research Center (SERC) to advance the state of the art in Systems Engineering. The additional costs to the Department and uncertainly imposed on the defense industrial base, especially the small business community, hinder the innovative capabilities needed by the Combatant Commanders (COCOMs) for their area of operations. A long-term continuing resolution is also impacting the basic science community, especially academia, with the delay of previously authorized FY2011 initiatives.

FY 2012 Alignment to Department Budget Themes

In his recent State of the Union address, President Obama declared the following;

> "This is our generation's Sputnik moment. Two years ago, I said that we needed to reach a level of research and development we haven't seen since the height of the Space Race. And in a few weeks, I will be sending a budget to Congress that helps us meet that goal. We'll invest in biomedical research, information technology, and especially clean energy technology — -- an investment that will strengthen our security, protect our planet, and create countless new jobs for our people".

We are here today to describe the FY 2012 President's Budget Request for the Department of Defense science and technology, to show how prior investments have maintained our technological edge and to show how the FY 2012 investment will continue to provide critical capabilities for our Nation's

[1] Science and Technology (S&T) is defined as the sum of basic research (6.1), applied research (6.2) and advanced technology development (6.3). Research and Engineering is S&T plus Advanced Component Development and Prototyping (6.4). Both S&T and R&E are activities that occur before initiation of formal acquisition programs.

security. The FY 2012 R&E budget of $25.88 billion supports the Department's FY 2012 budget themes and meets Secretary Gates' commitment to support the critical S&T needs of the Department[2].

The budget request contains 2.2 percent real growth in Basic Research (Budget Activity 6.1) and net 1.9 percent real growth across all S&T funding, compared to the FY 2011 President's Budget Request.

My testimony will provide an overview of the Department's S&T strategy and the key strategic initiatives in the FY 2012 budget and will outline recent accomplishments to integrate the Department's S&T and engineering activities. My colleagues will review their Component's projects in their respective testimony.

An Integrated Research and Engineering Enterprise

The Department's research and engineering enterprise encompasses a remarkable pool of talent and resources. Our footprint includes 67 DoD laboratories dispersed across 22 states with a total workforce of 60,000 employees; 35,400 of whom are degreed scientists and engineers, who conduct DoD-relevant research leading to key technology demonstrations and publish thousands of reports and peer-reviewed technical papers. In many cases, this community defines a technical field with seminal work and leads the industrial base in their respective areas.

We operate 10 Federally Funded Research and Development Centers (FFRDCs), 13 University Affiliated Research Centers (UARCs) and 10 Information Analysis Centers (IACs) across critical disciplines for the Department. These institutions enable the Department to connect with top technical talent across the Nation in fields ranging from cyber security to ballistic missile defense to advanced microelectronics and more. They provide objective systems engineering, objective red team assessments, gold standard test and evaluation, deep dive technical talent and innovative paths for rapid prototyping.

We also enjoy a strong relationship with industry and academia through a variety of programs designed to foster collaboration, including the Small Business Innovation Research (SBIR) program; Cooperative Research and Development Agreements (CRADA), and the DoD Reserve Officer Joint Reserve Unit (JRU) within ASD(R&E). In fact, in FY 2010, the Department issued approximately 2,000 SBIR Phase 1 awards (as a result of 12,000 proposals), and approximately 900 Phase 2 awards and engaged in approximately 2,500 CRADAs across a broad industrial base. Each of these is an avenue of innovation and a transition path to bring ideas into the Department and transition concepts developed in DoD Laboratories to commercial use.

Lastly, we continue to foster a strong relationship with future scientists and engineers. Our National Defense Education Program (NDEP) of DoD scientists and engineers in 26 states have engaged 180,000 students and 8,000 teachers. Our Science, Mathematics and Research for Transformation (SMART) program funds 670 undergraduate, graduate, and doctoral students in 19 DoD-relevant fields of study.

We are strategically shaping this enterprise to address a new set of technical and operational challenges for the Department. As described below, we have begun to focus our Laboratory, Basic Science, and Science, Technology, Engineering, and Mathematics (STEM) programs to address a common set of basic science emerging areas and S&T priorities. This will grow our technical talent pool in critical areas for the Department and provide industry and academia clear direction for future technical concepts and talent.

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[2] Office of the Under Secretary of Defense (Comptroller) / CFO, Fiscal Year 2012 Budget Request, February 2011.

Challenges for the Department's Research and Engineering Enterprise

We are in a period of remarkable change. Innovation, speed, and agility have taken on greater importance to our efforts given today's globalized access to knowledge and the rapid pace of technology development. For decades, the U.S. military's dominant operational capabilities were largely due to the continued development and delivery of superior technology by the defense research and engineering enterprise. In this environment, three factors have prominently shaped our thinking about the Department's S&T program:

1. **New technical capabilities for new Department missions**: The 2010 Quadrennial Defense Review (QDR) described the imperative to reshape America's military for today's wars while preparing for the most likely and lethal threats of the future.[3] It describes a complex and uncertain security landscape which requires new concepts and capabilities across the six key missions.[4] The Department's S&T enterprise has been successful in delivering capabilities to our Armed Forces to support the existing missions as well as emerging QDR missions, but there remain opportunities to create new capabilities that would provide utility across all mission areas.
2. **New approaches to overcome globalization of research and development:** The innovation environment that has been a hallmark of the United States since World War II, and the model for other nations, is evolving globally. The research and development (R&D) talent, financial resources, and manufacturing systems are integrated, but increasingly geographically dispersed.[5] The pool of experienced and talented researchers is increasingly globalized, led primarily by multi-national corporate R&D centers being established in new locations, many outside the United States. The recent acceleration in the development of research and development centers in Asia has been particularly rapid and far-reaching, as these economies grow.[6] This globalization has transformed technological innovation, lowered barriers across the globe for a wider range of actors to acquire advanced technologies, and potentially challenges the Department's ability to have assured access to leading-edge technologies.

   To mitigate this increased risk, we have strengthened collaboration efforts with our international partners to uncover and exploit potential scientific and technology breakthroughs, wherever they occur, and to contain whatever threats they may portend.[7] We have also launched a new initiative to develop the technical foundation for engineered resilient systems to mitigate supply chain vulnerabilities.
3. **Assuring the supply of Science, Technology, Engineering, and Mathematics talent for the Department:** Preparing for the future is a critical responsibility and our ability to provide future capabilities to our forces is contingent on our science and engineering talent. I am concerned about the future availability of science and engineering talent, particularly as we may see many of our exceptional scientists and engineers retire. By 2018, more than 60 percent of the federal workforce will be eligible to retire, and this figure includes many in our DoD laboratories.[8] I am also concerned that the defense industrial base, universities, and FFRDCs supporting the Department will also face science and engineering recruitment challenges. In our university, pipeline, the supply of qualified and interested U.S. students in the technical fields most relevant to defense is declining.[9] Today, over two-thirds of the engineers who receive PhDs from U.S. universities are not American citizens and recent data show many of these foreign-born

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[3] http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf

[4] The six missions are: Defend the United States and support civil authorities at home; Succeed in counterinsurgency, stability, and counterterrorism operations; Build the security capacity of partner states; Deter and defeat aggression in anti-access environments; Prevent proliferation and counter weapons of mass destruction; and operate effectively in cyberspace.

[5] S&T Strategies of Six Countries: Implications for the United States (2010), The National Academy Press, 2010.

[6] Ibid, p.4: "Experienced researchers are becoming harder to find in the U.S. and Europe, as Asian emigrant scientists return to attractive opportunities at home." Also, "Most U.S. and European Fortune 1000 companies already have multiple R&D centers and manufacturing sites throughout Asia, and they direct increasing shares of R&D budgets accordingly."

[7] National Research Council, Op. Cit. Key Recommendation 9-1.

[8] U.S. Senate Special Commission on Aging, Kohl Hearing, Legislation to Improve Federal Government's Hiring, Retention of Older Workers. See http://aging.senate.gov/hearing_detail.cfm?id=297184&.

[9] From: "Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5", p8, See: http://www.nap.edu/catalog/12999.html

graduates leave the U.S. to pursue careers in their native countries, or in countries with strong economies.[10] Our Science, Technology, Engineering, and Math (STEM) program is critical to ensuring the Department's future workforce. I will report on our STEM efforts later in this testimony.

These three factors – cross-cut capabilities for QDR missions; the globalization of research and development; and the decline in the supply of science and engineering talent convinced me that we need improved management models and imperatives to coordinate and guide our science and technology investments across the Department.

Department Science and Technology Executive Committee (S&T EXCOM)

In FY 2010, we established the DoD Science and Technology Executive Committee, which I chair, to implement improved coordination and to ensure a healthy and robust S&T enterprise. The S&T EXCOM is comprised of leadership from the Department's largest S&T organizations plus Under Secretary of Defense for Policy (USD(P)), Assistant Secretary of Defense for Nuclear, Chemical, and Biological Research, the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy (DASD(M&IBP)), and the Director, Joint Staff Force Structure, Resources, and Assessment Directorate (the J8). This body meets monthly to coordinate S&T strategic issues and to assure the Department's S&T investments are well-coordinated, focused on the highest-quality research efforts and responsive to current and future warfighter needs.

Inclusion of USD(P) has resulted in a close alignment of DoD S&T investments with Departmental policy. This has created opportunities for S&T to influence policy choices that in the past may not have had the benefit of wider options offered by emerging S&T concepts. Inclusion of the DASD(M&IBP) has opened opportunities for effective coordination of DoD S&T with defense industrial policy initiatives. Finally, the J8 has provided a key source for operational, warfighter input into the DoD research and engineering strategy.

Research and Engineering Imperatives

The Department's research and engineering enterprise is structured around the following four imperatives:

1. Accelerate the delivery of technical capabilities to win the current fight;
2. Prepare for an uncertain future;
3. Reduce the cost, acquisition time, and risk of major defense acquisition programs; and
4. Develop world class science, technology, engineering, and math capabilities for the DoD and the Nation.

Using these four imperatives as a framework, the remainder of this prepared testimony will give you information on our S&T activities over the past year and plans for FY 2012. The information provided focuses mainly on Departmental projects and initiatives funded by OSD program elements; information about Component activities is provided in the prepared remarks of my fellow witnesses at today's hearing.

[10] Ibid, p4, See: http://www.nap.edu/catalog/12999.html

Imperative 1: Accelerate the delivery of technical capabilities to win the current fight and develop the skills and processes to rapidly field capabilities in any future fight

The Department's research and engineering enterprise has undertaken a number of actions to improve the Department's ability to respond to COCOMs' needs, some which are urgent and needed immediately for current operations.

First, there has been a marked increase in the frequency and substance of connections to the COCOMs and their staffs. This is frequently done through personal visits to the Commander, in addition the OSD and component staffs conduct weekly and sometimes daily discussions with their counterpart COCOM staffs. These exchanges provide us with a front-line understanding of the operational challenges they face and the capability gaps they experience. Armed with this information we are better positioned to provide tailored solutions that address their highest priority concerns in a shorter period of time.

Second, we have strengthened connections with the COCOM Science and Technology Advisors. In Afghanistan, the Army's Research, Engineering and Development Command (RDECOM) leverages a network of Science & Technology Assistance Teams (STATs) and Science & Technology Acquisition Corps Advisors (STACAs) to gather and distribute first-hand knowledge of warfighter needs. RDECOM staff share what they learn with representatives across the Department. OSD is establishing a web portal to enable real-time direct exchange among the technical staffs, which better facilitates alignment of our investments with emerging COCOM needs. We also assist the COCOM staffs with analyses and field trials to refine the definition of capability needs and present candidate solutions. Several examples of delivered capabilities include the following.

Helicopter Alert and Threat Termination - Acoustic (HALTT-A) Program was discussed in testimony last year as an emerging capability.[11] The first two demonstrators have since been tested at the Army Aberdeen Proving Ground, sent to the 10th Combat Aviation Brigade at Ft. Drum for flight testing and has been deployed to theatre in Afghanistan protecting our troops. The systems have collectively logged more than 820 hours of mission time (351 missions) and are providing valuable operational data for future improvements. All of this was done in less than 12 months in close cooperation with Army Aviation and the Joint Staff.

Gunslinger Package for Advanced Convoy Security (GunPACS) provides enhanced situational awareness and cooperative engagement capabilities for ground and combat logistics elements in Afghanistan. Utilizing networked data fusion, such cooperative engagement enables more accurate and effective fire. In less than three months, four prototype systems were readied for operational deployment to the 1st Marine Division.

Mobile Modular Command and Control (M2C2) provides on-the-move, over-the-horizon communications and digital command and control (C2). The capability, delivered on an MRAP to Afghanistan, includes an integrated suite of tactical radios, broadband satellite communications, and staff kits with secure wireless network connectivity. This capability was fielded in seven months.

eXperimental Fuel Cell (XFC) Submerged Launch is a long endurance, stealthy (small and electric propulsion) unmanned aerial system (UAS) equipped with high quality real-time or stored video, capable of being launched from a submerged submarine or platform. Started in May 2010, this capability is being readied for delivery.

Low Collateral Damage Munitions is the work the Air Force is undertaking to develop munitions that minimize collateral damage – an important capability identified by the COCOMs. Munitions scientists from the Air Force Research Laboratory teamed with the Lawrence Livermore National Laboratory to design and test an advanced composite-case warhead that disintegrates during the

[11] Prepared Statement of Zachary J. Lemnios, Testimony before the United States House of Representatives Committee on Armed Services Subcommittee on Terrorism, Unconventional Threats and Capabilities, 23 March 2010.

explosion and minimizes fragmentation, thus decreasing damage and injury to nearby structures and personnel, including friendly forces and innocent civilians.

Third, the Department improved the Joint Concept Technology Demonstration (JCTD) program processes with a focus on speed and flexibility. Seventy seven percent of JCTD new starts are on track to rapidly develop and demonstrate new concepts, with two years set as the objective threshold. This is a marked improvement from 2009 where less than 20 percent of JCTD new start projects were completed in less than three years. Given the globalization of research and development it is important to accelerate the demonstration of innovative concepts and technologies, and field those that offer the most promise faster than our adversary. The JCTD program is instrumental in meeting that objective. Areas of increased emphasis for this program in FY 2012 include:

- COCOM and interagency data sharing for enhanced warning and control;
- Enhanced force protection through the use of unmanned/remotely piloted systems for troop resupply;
- Improvements in cyber infrastructure to protect classified networks;
- Improved Intelligence, Surveillance and Reconnaissance research, developmental, testing and evaluation (RDT&E) integration venues;
- Biometric and forensic S&T initiatives for both collection and rapid exploitation.

Fourth, we are leveraging our Small Business Innovation Research (SBIR) community to field capability to the warfighter faster. Within the Office of the Secretary of Defense, we have launched an SBIR Pilot Program to identify several SBIR projects which are addressing COCOM needs. We plan to support Phase II prototypes, including access to ranges to rapidly demonstrate their inventions in realistic warfighting conditions. Since we are working closely with COCOM representatives in this process, we expect this pilot to result in exciting, innovative capabilities from our Small Business community that directly address some of the most urgent needs of our warfighters.

Imperative 2: Prepare for an uncertain future

The Department's investments in basic research, S&T priority areas and joint service engineering concepts and testbeds are critical enablers of technological superiority, and by extension, operational advantage. Each of these efforts builds the technical capabilities for new Department missions.

The Department's Basic Research Program

The Department's basic research program paves the way for our technological future – the scientific discoveries it yields today provide the foundation for tomorrow's capabilities. Given the increased global emphasis on research and development, the U.S. cannot assume an assured technological superiority on the battlefield: to do so it must remain on the scientific cutting edge. The President's commitment to an appropriately funded basic research program is reflected in the Department's FY 2012 budget request. This represents a $79M increase to $2.078B, or 2.2 percent real growth in basic research accounts compared to the FY 2011 President's Budget Request. The increase has been inspired by recent basic research successes made possible by DoD funding. For example,

- The 2010 Nobel Prize was awarded for the discovery of graphene, which will likely lead to a new generation of electronic materials. DoD-funded research was instrumental in understanding the far-reaching implications of this research.[12]
- The microbial fuel cell, cited by Time Magazine as one of the 50 top inventions in 2009, can produce electricity at the ocean floor by bacteria-reactions and bacteria-nanowires.[13]

[12] Y. B. Zhang et. al ., Nature, 438, 201 (2005)
[13] L. M. Tender et.al., Nature Biotechnology, 20, 821 (2002)

- Recently, quantum coherent processes have been demonstrated that have extremely long lifetimes at room temperature. This opens the door to new sensors, precision metrology and extremely secure communication over long distances without the need for extensive cryogenics.[14]
- DoD-supported researchers demonstrated a "spaser" (surface plasmon laser) that emitted 564nm light from a 44nm composite particle. The implication of this device is that it allows for faster electronics while avoiding current limitations due to heat generation.[15]
- New paradigms of information processing were developed, based on the spin of the electron in addition to or in place of the charge.[16]
- Over the past year, Human Social Cultural Behavior (HSCB) researchers have developed tools for joint analysts to rapidly and accurately understand the impact of crowd sentiments, and tools for planners to develop courses of action and assess their impact on a commander's objective.

Over the past year, the Department assessed the basic research areas for investments that represent future high potential/high opportunity. For example, advances in engineered materials that have unique properties not found in nature have the potential for launching a new generation of computer chips, for greatly accelerating signal processing for DoD needs and for achieving super-convergent optical beams not previously possible. A new field – quantum information and control – exploits the spectacular, recent advances in controlling matter in the laboratory at the level of the individual atom. The full capabilities of this emerging field are not yet fully known, but resulting technologies will likely show up in secure communications, ultra-precision sensing, navigation, materials simulation, and data manipulation. Those who explore and exploit these and other disruptive areas, including synthetic biology, nanotechnology, cognitive neuroscience, and modeling of human and societal behavior, will likely gain an important competitive edge in warfighting capabilities.

Basic Research is fundamentally about creating knowledge, and innovation occurs when that knowledge is used in creative ways. The Department believes sharing basic research information helps advance the progress of knowledge and in the past year reaffirmed and extended its policy towards removing restrictions on publication of fundamental research results.

The Department's S&T Priorities

In FY 2010 and early FY 2011, we gathered over 200 scientists, engineers, operators and subject matter experts from across the Department and launched a comprehensive study to derive a set of S&T priorities to support the six QDR mission areas. This effort built upon the important work accomplished during the QDR deliberations in 2009 and 2010 and was modeled after two recent Defense Science Board Studies.[17] [18] Our study outlined the operational architectures, critical capabilities, and enabling technologies to support each of the six missions. We identified a set of seven cross-cut capabilities that are critical to one or more of the mission areas.

The S&T EXCOM chartered a Priority Steering Council (PSC) for each area to develop research and engineering 'roadmaps' to inform and guide Department S&T investments over the Future Years Defense Program and beyond for each of these seven areas. Members of the PSCs include DoD S&T enterprise senior-level subject matter experts from all components with investment or interest in an area and experts from outside the Department.

The Department S&T Priorities are inclusive of the entire DoD S&T enterprise, and are meant to be in addition to Component specific priorities:

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[14] M. Ledbetter et. al., Photonics Spectra, December 2010 pg 17
[15] M. A. Noginov et. al.,Nature, 460,1110 (2009)
[16] S. A. Wolf et. al., Proceedings of the IEEE, 98, 2155 (2010)
[17] Defense Science Board 2006 Summer Study on. 21st Century Strategic Technology Vectors
[18] Defense Science Board. 2008 Summer Study on Capability Surprise

- **Cyber Science and Technology -** science and technology for efficient, effective cyber capabilities across the spectrum of joint operations.

- **Electronic Warfare / Electronic Protection -** new concepts and technology to protect systems and extend capabilities across the electro-magnetic spectrum.

- **Data-to-Decisions -** science and applications to reduce the cycle time and manpower requirements for analysis and use of large data sets.

- **Engineered Resilient Systems** - engineering concepts, science, and design tools to protect against malicious compromise of weapon systems and to develop agile manufacturing for trusted and assured defense systems.

- **Counter Weapons of Mass Destruction** – science and technology to improve DoD's ability to locate, secure, monitor, tag, track, interdict, eliminate and attribute WMD and materials.

- **Autonomy** – science and technology to achieve autonomous systems that reliably and safely accomplish complex tasks, in all environments.

- **Human Systems** – science and technology to enhance human-machine interfaces to increase productivity and effectiveness across a broad range of missions.

Joint Engineering Concepts and Testbeds

The Department's investments in joint engineering concepts and testbeds are executed out of ASD(R&E) and include the Joint Capability Technology Demonstration (JCTD) program and other efforts that apply broadly across the Department.

Adaptive Versatile Engine Technology (ADVENT)

The ADVENT program is developing engine technologies that provide optimized fuel efficiency and performance capabilities that could yield 25 percent or greater increase in engine fuel efficiency. ADVENT should provide a suite of revolutionary technologies for a range of air vehicles, including future and legacy turbine engine propulsion systems supporting subsonic and supersonic long-range strike, tactical aircraft, strategic and tactical mobility, and intelligence, surveillance, and reconnaissance operations.

The ADVENT program is a cooperative funding effort between the U.S. Air Force and OSD and leverages industry independent research and development efforts. The program is making excellent progress with successful completion of an adaptive fan test, a key milestone, and is on track to conduct the prototype engine demonstrations in FY 2013..

Airborne Laser Test Bed (ALTB)

The Department terminated the Airborne Laser Program in 2009, and determined the best use for the existing aircraft was as a research and development test bed. As a result, the Missile Defense Agency established the Directed Energy Research (DER) Program, which includes the ALTB and other directed energy technology development programs. The ALTB beam control system is the most sophisticated beam control system built, and the only one integrated with an aircraft. As an S&T resource the ALTB offers risk-reduction opportunities for future airborne systems in the areas of target acquisition, tracking and pointing (ATP), jitter control, optical degradation from boundary-layer turbulence, lethality, adaptive optics, contamination control and mitigation, precision tracking/handover testing, and thermal blooming compensation. The Department conducted a study that confirmed ALTB is an important national test asset and should be kept to advance directed energy research and development. We seek your support for the Fiscal Year $96M request for the MDA directed energy research.

Cyber Science and the National Cyber Range (NCR)
As a new operational domain, the Department included two new Defense-wide Program Elements (PEs) in the FY 2011 budget to extend the technical underpinnings for cyber operations. These program elements are in the FY 2012 budget request as well. The Department requests your support for the Defense-wide Cyber Security Applied Research and Cyber Security Advanced Technology Development new-start programs, which integrate and transition collaborative research across DoD. In the FY 2012 budget request, the Department is also seeking an increase in the DARPA cyber programs. We see these efforts as complimentary; the OSD program will address architectures while the DARPA program will address high-risk, high-payoff approaches.

The Department considers the ability to operate in cyberspace as essential.[19] Focused and innovative projects, from basic research to advanced development, remain a high priority for investment. Much work needs to be done to understand cyber and protect against capabilities being developed by a growing number of potential cyberspace adversaries. It is important to develop specialized active defenses that make it extremely difficult to impossible for cyberspace adversaries to attack or penetrate our systems.

We believe it is also necessary to strengthen the scientific basis, at the most fundamental level, for cyber security. Last year we commissioned a study by the JASONs, a panel of world-class scientists, to establish the scientific foundations of cyber security.[20] The report and the Air Force's new Multidisciplinary University Research Initiative on the Science of Cyber Security represent the beginnings of new approaches to determine better ways to the existing cycle of developing cyber security measures and countermeasures to dynamic cyber threats. More work will follow in this area.

An example of a successful transition is the adoption and use by various organizations across the Department of the award-winning Lightweight Portable Security capability, developed by the Air Force Research Laboratory, which creates a bootable, safe, self-contained environment on un-trusted commodity computers. The technology enables authenticated users to safely connect to trusted DoD servers and conduct DoD business securely without exposure to local malware.

The Department is leveraging its Small Business Innovation Research program for cyber security research; with 46 SBIR projects in 2011. Additionally, the Department, in partnership with the Department of Homeland Security (DHS), is hosting the 5th annual Cyber SBIR Workshop this summer to bring small businesses and commercial integrators together with DoD and DHS user organizations and accelerate transition of SBIR investments.

In keeping with the goals of President Obama's Cyberspace Policy Review, DARPA has created important enabling technologies under the National Cyber Range Program. These advanced technologies enable the emulation of networks at large scale, providing researchers with opportunities to experiment with new cyber security approaches, including network architectures; additionally, operators can test new concepts for cyber operations. Later this year, prototypes will be built and tested by DARPA and United States Cyber Command (US CYBERCOM) employing new use cases and technology. We have formed an interagency working group, comprising at its core OSTP, DoD, DHS, DoC (NIST), and NSF, to work with DARPA and US CYBERCOM to transition the prototypes across the U.S. Government.

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[19] William J. Lynn, "Defending a New Domain", Foreign Affairs, 2010.
[20] JASON Report (JSR-10-102), *Science of Cyber-Security*, the MITRE Corporation, November 2010.

Joint Experimental Range Complex (JERC)
The Joint Experimentation Range Complex (JERC) at Yuma Proving Ground in Arizona is one of DoD's premiere sites for the assessment and evaluation of technologies for combating terrorism and fighting insurgencies. First built in 2003, the three separate JERC sites that make up the complex provide a comprehensive capability that represents many aspects of the tactical environment which U.S. forces currently operate. The JERC sites provide an open, accessible, and operationally representative environment in which companies can assess, evaluate, and mature their capabilities prior to fielding. In 2010 alone, more than 120 potential solutions from multiple developers were evaluated under the sponsorship of the Rapid Fielding Directorate (RFD).

A wide variety of technologies are routinely evaluated at the JERC sites to include counter-IED electronic warfare and detection systems, advanced Information, Surveillance, and Reconnaissance (ISR) Systems, and manned and unmanned vehicles. The RFD and the Joint IED Defeat Test Board manage the test efforts in a cooperative fashion to maximize utilization of the complex and to prevent duplication of investments. Employing a unique process to assess new technologies for further development or rapid deployment, the RFD canvasses the developmental communities for potential solutions to identified needs, and then assesses those solutions by facilitating and resourcing evaluation periods with an independent government test director. This process provides developers of novel solutions direct access to the JERC's capabilities, including small businesses that otherwise would not have access to these capabilities. RFD-sponsored testing is typically conducted on several technologies during one- to two-week blocks every seven weeks. The JERC is currently staffed to sustain 6-day-per-week/24-hour coverage. The range support contractor has approximately 80 temporary on-call employees to support surge operations during intensive test periods. Current staffing is approximately 28 government and 320 contractor personnel.

Two of the JERC sites replicate urban warfare sites in a desert environment, and the third replicates desert mountain roads typical of Afghanistan. The range is heavily instrumented to support counter-IED test activities; essentially all test data are acquired on a real-time basis, facilitating rapid analysis of test results. The physical terrain features provide a very challenging environment to stress materiel solutions prior to deployment. In addition to natural terrain, significant urban environments have been developed including over 400 buildings constructed from realistic methods including adobe brick, concrete, and wood. The road network was constructed based on intelligence information on roadways and replicates the enviroments that were used for some of the deadliest attacks against U.S. and coalition forces.

Representative threat systems, including complex cellular and wireless networks, are maintained to represent the measures used to defeat our countermeasures. To complete the representation of the environment, the JERC includes a robust representation of the radio frequency environment, which has proven invaluable in testing electronic warfare and threat detection systems. The JERC is equipped with modern instrumentation systems and fiber optic data networks that allow for efficient and rapid data collection.

Our efforts at the JERC expand existing test and technical infrastructure to develop an effective capability evaluation and fielding approach that anticipates and rapidly responds to emerging threats. Our adversaries have repeatedly demonstrated the ability to quickly neutralize U.S. or coalition capabilities with inexpensive, relatively inefficient weapons such as IEDs. This operational reality demands that the United States continue to accelerate the development and fielding of new capabilities in order to adapt faster than the enemy.

Trusted Defense Systems
To strengthen our trusted systems effort, the Department is implementing a Strategy for Systems Assurance and Trustworthiness, as reported to Congress in 2010. The Strategy consists of activities in four key elements: mission criticality as a priority, comprehensive

approach to program protection, industry engagement, and advanced detection of vulnerabilities. This strategy provides program and system managers tools to assure hardware and software. It also instills system security engineering as a fundamental discipline to manage risk commensurate with the criticality of, and threats to, the weapon system. The strategy will enable program and system managers to minimize the chance that system performance is impaired through supply chain risk management and secure system design.

Secure Microelectronics Supply Chain
Much of the world's accessible microelectronics is fabricated by and under the control of foreign companies; many foundries are located offshore. Offshore chip design and manufacture present adversaries with opportunities to introduce malicious code or to corrupt chip design, rendering our weapon systems vulnerable to non-kinetic attack.

The Strategy for Systems Assurance and Trustworthiness will enable program and system managers to conduct supply chain risk management (SCRM) throughout a weapon system's lifecycle. This strategy builds on past studies and programs to provide program and system managers with tools to manage risk in a manner commensurate with the criticality of, and threats to, the weapon system.

The Department Trusted Foundry Program (TFP) is part of this effort. The TFP ensures the defense industrial base has access to leading edge, and secure, foundry technology at IBM and more than 90 additional microchip-related services at 46 other trusted suppliers.

The Defense Microelectronics Activity (DMEA) ensures the TFP's viability. DMEA is responsible for the accreditation of the trusted suppliers and they are the trusted manufacturing source for replacement chips no longer available from commercial vendors. The FY 2012 budget equipment upgrades to DMEA's facility to manufacture 90nm chips – a needed capability to keep DMEA as a supplier of last resort for trusted components no longer available from commercial suppliers

High Performance Computing Modernization Program (HPCMP)
The Department funds the High Performance Computing Modernization Program (HPCMP) to provide super-computing services to DoD's scientists and engineers. It is instrumental to a number of DoD communities. For example, the Developmental Test community uses the HPCMP for a wide range of test activities to include augmenting or replacing expensive wind-tunnel testing and predictions for armor performance against improvised explosive devices. There are six DoD HPC Centers. Over the past 18 months the Department reviewed the capabilities, functions, and value of the existing HPC program. The study yielded a number of recommendations to increase efficiencies, and these recommendations are being implemented. For example, the study identified several HPC-linked software development projects had reached sufficient maturity and will transition to other programs. Additionally, the Maui Super Computing Center is to be designated as a "green computing" Energy Efficient Center of Excellence and will pursue research to reduce super-computing power consumption, an important goal not only for DoD, but for all national users of HPC equipment. A further recommendation is that the HPC program be linked more closely to Service acquisition programs. In FY 2012, the HPC program will transfer from OSD to Army program management.

Systems 2020
While the Department strives to improve its processes and workforce to reduce the cost, acquisition time, and risk of major defense acquisition programs, we are also starting a technology development effort, Systems 2020, with the objective of significantly advancing the state of engineering practice and productivity in delivering adaptable and trusted systems. Systems 2020 is a part of an umbrella science and technology priority designated by the S&T EXCOM: Engineered Resilient Systems (ERS).

The Systems 2020 program will seek new concepts and tools for the design of adaptable systems. Systems complexity remains a key challenge – past and current research and development efforts resulted in highly capable, but individually complex, software and hardware components. As a result, overall system complexity has increased significantly resulting in design delays, reduced flexibility, and increased system delivery cycles. The Systems 2020 effort will explore new concepts to integrate advanced engineering models that result in systems that are inherently more adaptable across mission sets and environments. The key idea is investigating advanced digital design approaches that enable engineers and warfighters to rapidly model and iterate new ideas under various operational conditions and recommend design approaches for instilling adaptable capabilities into the platform. Since it is becoming increasingly difficult to predict missions and operational environments, tools that enable understanding and design of adaptability into our platforms will be of enormous benefit to our forces.

The program will also research new concepts for design tools that enable real-time assessment of the security risks involved in systems design when using components from un-trusted sources. Manufacturers use components sourced by a global supply chain which increases risks for compromise of our systems; design tools that enable the understanding of the tradeoffs among performance, risk, and cost are needed.

We cannot remain competitive and responsive with a sequential, fixed requirement focused engineering design and manufacturing capability. Model based and platform based technologies and tools offer game changing opportunity to transform engineering practice to efficiently create, field, and evolve trusted defense systems which can readily adapt to inevitable changes in threat, technology and mission environments.

Data-to-Decisions

Increased investments in Information, Surveillance, and Reconnaissance (ISR) capabilities have resulted in many new deployed sensors yielding data in terabyte amounts that many thought inconceivable just a few years ago. The increased number and type of sensors have been critical to support our troops' efforts in Afghanistan and Iraq, and wherever they conduct the war on terrorism. These threats are usually small groups of individuals who quickly adopt new concealment tactics to evade detection, including hiding among the indigenous population. While the Department has been very successful in delivering ISR capabilities, this accomplishment has resulted in what some senior military commanders are characterizing as 'data deluge.' There has been insufficient progress in building effective technology to exploit this exponential growth in data. As a result, our warfighters are not able to use the data to gain a situational awareness advantage against adversaries, many of whom operate from sanctuaries in complex, dynamic environments.

To address the difficult challenges of making rapid operational decisions in the face of overwhelming volumes of data, we have launched a joint Data-to-Decisions initiative that will advance military decision support systems. The key goal is to develop an open-source architecture system that enables rapid integration of existing and future data exploitation tools, no matter who delivers the tools. The program will create libraries of analytic and user-interaction modules that can be repurposed across a multitude of joint missions. It will achieve this using a proven "build-test-build" process that iteratively improves technical components by providing "real-world" data sets to a contractor and academic consortium with oversight from front-line operators. Through this program, the rapid development and maturation of new decision support systems will provide the necessary tools to mine important threats and relationships from massive data sets.

Investments in Data-to-Decisions research will enable operators and analysts to organize and assess vast amounts of data. Development of capabilities to understand the human, social, cultural, and behavior dimensions is equally important to understanding the data in

context of diverse cultures, and employing these insights to successfully achieve objectives in joint operations.

Technology Forecasting
The rapid rise and progress of science and technology developments around the world have increased the risk for technology surprise to our forces. In response, the Department is launching a new effort to develop modern tools that will incorporate scientific, intelligence, and international community inputs into a modern technology watch and forecasting framework.

The program will use current advances in computational and analytic capabilities to identify science and technology areas of concern or opportunities where the Department should invest. It will start with an in-depth analysis of technology forecasting methods that have been used in the past and their successes in predicting trends. The knowledge gained will provide a baseline for comparison of novel methods, approaches for aligning both qualitative and quantitative approaches within a broader foresight program, and metrics and methods for understanding accuracy and establishing ground truth.

We work closely with both the Intelligence Community and our Allies to ensure we leverage expertise, are challenged by orthogonal approaches, and ensure broad and deep thought diversity in 'red-teaming' not only our results but also our foundational methodologies. The results from this program will be used to better connect our researchers with key research activities occurring around the world.

Imperative 3: Reduce the cost, acquisition time, and risk of major defense acquisition programs

To be successful today and in the future, the Department's research and engineering enterprise promotes innovation in process, design, and engineering while achieving productivity growth, and "to learn to do more without more." To improve our success in acquisition programs, the Department has worked to enhance our engineering and test and evaluation policy and guidance and to improve the capability and capacity of our engineering and test and evaluation workforce.

Last year, the Department continued to develop Systems Engineering (SE) policy and guidance to drive better technical performance through the application of SE principles and best practices for the Department's acquisition programs. For example, in a major effort to improve technical effectiveness and operational efficiency, the Department undertook a dramatic streamlining of the Systems Engineering Plan (SEP) to reduce duplication with other milestone document submissions. This revision to the SEP makes it more useful, more technically complete, and more pertinent. This year, the Department will oversee initial applications of the revised SEP outline as "expected business practice" and will adjust the format and content based on feedback from implementation on upcoming programs and new statute and policy.

In September, 2010, the Department issued Developmental Planning (DP) policy to establish elemental DP principles in support of defense acquisition. As a result of this policy, the Services are engaged in fostering technical analysis and planning much earlier in the acquisition life-cycle. These engagements promote identification of technical risk before the Department makes large resource commitments to the development of proposed materiel solutions, and have resulted in deeper understanding of capability gaps and the refinement of initial acquisition phase activities. We established a department-wide DP working group to assist the Components in implementing this new policy, to disseminate the most recent information on OSD guidance, to share Component DP policy and implementation strategies; and to share lessons learned across the Department.

An important part of the Developmental Planning initiative is to ensure Materiel Development Decisions are made with the full needs of the user capability in mind so the systems we acquire are

engineered to work effectively as part of system of systems. Increasingly, capabilities both within and across the Services, require engineering attention at the capability level and systems engineering for systems of systems has become more important. We published a guide to Systems Engineering for Systems of Systems which is being used in a variety of capability areas, we have been working with the Services to support their efforts to apply systems engineering for systems of systems, and we are now looking at how we ensure that we consider the role new systems play in current and prospective systems of systems as we develop new system concepts

The Department has also assessed existing DoD reliability policy and proposed actions to improve effectiveness of the current DoD 5000.02 policy. This assessment resulted in a draft policy requiring early and continued emphasis on Reliability and Maintainability engineering and test activities throughout the lifecycle:

The Department's SE personnel are engaged throughout the acquisition lifecycle to help shape a program's technical and management processes, ensure positive outcomes, and increase the probability of program success. SE participates in technical reviews of MDAPs, particularly the Preliminary Design Review (PDR) and the Critical Design Review which help inform the Milestone Decision Authority. SE participation provides ground-truth for assessment of these reports, and, in the case of the PDR, informs the Milestone Decision Authority's 2366b certification activities. Other activities include:

(1) **Program Support Reviews** (PSRs) are conducted to support pending Overarching Integrated Product Team program reviews, requests by the USD(AT&L), and requests from Program Managers. Systemic root cause analysis performed on PSR findings shows that the adequacy of staffing is the most prevalent issue in program offices.

(2) **Nunn-McCurdy Reviews** assess SE and risk management in support of certification reviews following a Nunn-McCurdy breach.

The Department's Developmental Test and Evaluation (DT&E) personnel also engage throughout the acquisition lifecycle to provide an impartial evaluation of a program through T&E expertise to identify key issues and risks needing design resolution before production. The primary T&E product at technical reviews is credible knowledge of a system, a component, or technology maturity as well as the ability to provide the end-user with a characterization of a system's capabilities and limitations. DT&E has increased focus on support to Program Managers by reducing burdensome and manpower intensive oversight requirements. DT&E insight and influence comes from early and continuous engagement with programs.

As part of the Department's Trusted Defense Systems strategy SE made significant advancements during 2010 to streamline, update and apply program protection and supply chain risk management policy, guidance and methods. SE personnel have developed a criticality analysis methodology, engineering guidance for system security, and updated the reporting format for program protection plans required at every milestone review. We have engaged with acquisition programs, supporting identification of critical components and shaping the risk mitigation strategy for software, hardware, or firmware vulnerabilities and supply chain exploit. We have also reached out to industry in the development of best practices and to develop a new discipline for system security engineering.

A key focus within the Department's research and engineering enterprise is to ensure (1) that the Department's engineering workforce is trained and certified to meet the needs of complex SE efforts and (2) that the Department's T&E workforce is also trained and certified to conduct testing, verification and validation of program capabilities. We have launched a comprehensive survey of the Department's Systems Planning, Research, Development and Engineering (SPRDE)-certified engineering workforce. This survey will assess the current competencies and identify any skills gaps that may exist between the workforce's current capabilities and those needed to meet current and future mission requirements. This assessment and resultant gap analysis will help shape future workforce development and human capital planning initiatives.

We have established several engineering workforce development initiatives to address the growing department and industry challenge of attracting and retaining the most qualified systems engineering technical leaders to address defense acquisition challenges. These initiatives include implementation of the engineering portion of the Key Leader Professional Development program, working with the defense industry and engineering professional organizations on education and training initiatives, and conducting national and international workshops that explore lessons learned in systems engineering education, training and experience development. We are also analyzing the T&E workforce to understand the breakdown of personnel performing the DT&E mission across the Components. We plan to launch a comprehensive competency assessment to identify the gaps in skills, education, and training of the T&E workforce. This assessment will be used to update the Defense Acquisition University curriculum in FY 2012. In addition, we are enhancing the T&E education certification criterion to include a technical or science degree.

Both the program Lead Systems Engineer and the program Lead Test and Evaluation were formally established in 2010 as mandatory Key Leader Positions. This will clarify organizational authority and responsibility for SE and T&E within program offices and will strengthen technical engagement in major defense acquisition programs.

Also important to the Department's efforts in this imperative is the Systems Engineering Research Center (SERC). The SERC is a DoD University Affiliated Research Center which brings together a broad consortium of universities from across the United States to advance the state of the art in Systems Engineering. In FY 2010, we sponsored SERC research tasks to explore future systems engineering workforce competency needs and to investigate new approaches to cultivate, educate, and prepare the future SE workforce. These tasks include research in support of the development of an authoritative SE body of knowledge, development of a graduate reference curriculum for systems engineering, and methods for incorporating systems thinking into undergraduate engineering capstone courses. The SERC has recently performed key work in developing tools to quickly and graphically define a concept of operations for our systems, so that as missions and environments change, our warfighters can quickly articulate their needs. Further SERC research efforts in 2011 are on hold pending release of funds under the continuing resolution, and we seek your support to provide funds in FY 2012 for this effort.

At the direction of the BETTER BUYING POWER memorandum[21], and to improve the efficiency and effectiveness of technology maturity assessments for Major Defense Acquisition Programs (MDAPs), the Department over the last year developed a revised Technology Readiness Assessment (TRA) process to replace the traditional TRA previously used. Compared to the prior TRA process, the new TRA process reduces the total number of required assessments and streamlines those assessments that are conducted. This increased efficiency is achieved by firmly affixing responsibility for technology maturity risk identification and mitigation on Service Acquisition Executives and Program Managers vice OSD staff.

This new TRA process is still in development and may be adjusted to reflect feedback during initial execution. However, I believe that it will result in clearer roles and responsibilities among OSD and the Services that will sharpen the focus on technology maturity while simultaneously increasing efficiency and reducing overhead burden.

During this migration to the new TRA process, the Department continues to conduct "traditional" TRAs and performed over twenty in the last year. These assessments sharpened the program managers' focus to effectively address the risks of technology insertion. For example, the TRA for the GPS IIIA program identified a technology maturity challenge for extremely accurate and stable atomic clocks. Subsequently, GPS IIIA conducted the recommended space qualification testing to demonstrate adequate clock reliability. I expect that the new TRA process will also directly support programs while simultaneously providing Congressional and DoD leadership oversight

[21] http://www.acq.osd.mil/docs/USD_ATL_Guidance_Memo_September_14_2010_FINAL.PDF?transcriptid=4648

Imperative 4: Develop world class science, technology, engineering, and math capabilities for the DoD and the Nation

The final imperative addresses the goal of developing world class science, technology, engineering, and math capabilities for the DoD and the Nation. As President Obama said in the State of the Union address, "Maintaining our leadership in research and technology is crucial to America's success. But if we want to win the future – if we want innovation to produce jobs in America and not overseas – then we also have to win the race to educate our kids."

The Department depends on the technical skill and exceptional aptitude of its research and engineering workforce in its labs, in the defense industrial base, and in universities for innovation and success in the research and engineering initiatives designed to meet national security challenges. Ensuring our future workforce will possess the technical competencies necessary to meet future needs is an increasing challenge, and the FY 2012 budget requests funds for Science, Technology, Engineering, and Math (STEM) programs to ensure we meet the challenge.

In May 2010, the Department submitted to Congress its STEM Education and Outreach Strategic Plan. This plan, developed by 27 senior leaders from across the DoD, lays out our vision to develop a diverse, world-class STEM talent base by. The implementation strategy strengthens our STEM education and outreach portfolio and provides for specific processes and measurement criteria. The strategy includes a STEM governance architecture consisting of a DoD Executive Board, and links to the newly formed National Science and Technology Committee (NSTC) on Education and a defense industry forum.

Core to the strategy is the National Defense Education Program (NDEP). NDEP invests in inspiring, developing, and attracting the current and new generation of STEM talent. NDEP also enhances students and world-class researchers' interest in DoD by offering opportunities for direct engagement with DoD labs and Component technical staff.

NDEP's K-12 program enhances STEM education through public-private engagement between DoD and local schools and organizations. DoD research and engineering professionals serve as direct conduits for inspiring students to learn STEM and, in the process, motivate many to pursue STEM careers. Currently, 1,750 DoD scientists and engineers in 26 states have engaged 180,000 students and 8,000 teachers.

The Science, Mathematics and Research for Transformation (SMART) program funds 670 undergraduate, graduate, and doctoral students in 19 DoD-relevant fields of study. SMART is a scholarship-for-service program - participants commit to one year of DoD employment for each year of academic support received. Since 2006, nearly 300 students have transitioned into the DoD workforce. The program is popular – we received 2,800 applications earlier this year and selections will be made soon.

The National Security Science and Engineering Faculty Fellowship (NSSEFF) focuses on distinguished scholars and graduate students. The program awarded long-term funding to 29 distinguished university faculty members to conduct basic research on topics essential to national security. Connections to the faculty enable the program to leverage more than 150 students and postdoctoral scholars serving on research teams. The NSSEFF enables partnerships between the faculty and their research assistants with scientists and engineers in the DoD laboratories, providing us opportunities to identify and recruit top talent.

The Systems Engineering Capstone pilot program is designed to increase systems engineering skills in engineering students, and increase the pipeline of systems engineers available to DoD. The program inspires students to solve the types of system engineering challenges evident among DoD programs. Three hundred undergraduate and graduate students at eight universities and six military institutions (Naval Postgraduate School, Air Force Institute of Technology, United State Military Academy, United States Naval Academy, United States Air Force Academy, and U.S. Coast Guard Academy)

participate in the pilot program along with DoD civilian, military, and industry personnel who participate as mentors.

The President's Budget FY 2012 funds these NDEP programs, and we will look for more opportunities to further strengthen the Department's STEM activities.

Conclusion

Mr. Chairman, we are strategically shaping the Department's research and engineering enterprise to address a new set of technical and operational challenges for the Department. The QDR identified a series of missions where our forces must dominate, from irregular warfare to traditional conventional high-end warfare, where new challenges to access are emerging. The S&T EXCOM identified seven science and technology priority areas for investment that would provide dominant technical advantages across the mission space, for the near-term and the future. We now live in a world where research and development efforts are globalized, increasing the chance for technical surprise. Our basic research program and technology watch programs have been re-structured to ensure our scientists are involved early in potentially disruptive emerging science fields; history proves those who explore and exploit early advances will likely gain an important competitive edge in warfighting capabilities. We realize that our technical goals are only achievable with exceptional research and engineering talent and our STEM programs provide the resources and strategy to train and recruit the workforce we will need.

The President's budget addresses both important aspects -- people and programs – and I ask for the Committee's support for the requested funds.

Secretary Gates testified last month that "We still live in a very dangerous and often unstable world. Our military must remain strong and agile enough to face a diverse range of threats..."[22] I want to give you my personal assurance that I will work tirelessly to ensure the Department's research and engineering enterprise is focused and properly resourced in people and programs to keep our military strong and agile. I look forward to working with you in the months ahead as we meet the challenges of winning the current fight and preparing for the future.

[22] Prepared Statement of Secretary of Defense Robert M.Gates to House Armed Services Committee, February 16, 2011; Pg. 8.

Zachary J. Lemnios

Assistant Secretary of Defense for Research & Engineering for Department of Defense

The Honorable Zachary J. Lemnios was confirmed by the United States Senate on June 19, 2009 and sworn in on July 2, 2009. The Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) is the Department of Defense's (DoD's) Chief Technology Office, providing thought leadership for the Department's near-, mid- and far-term research and engineering efforts to develop the technical capabilities to support the Secretary of Defense goals and priorities and the principal staff advisor for research and engineering matters to the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)).

ASD(R&E) implements its mission by operating in a culture of innovation, speed, and agility to rapidly develop breakthrough technologies, prepare for an uncertain future and strengthen the foundation of DoD's acquisition programs through scientific and engineering support. As DoD's Chief Technology Office, ASD(R&E) operates in collaboration and cooperation with industry, academia, and government S&T organizations – the "Research Triple" – to discover, develop, and deploy new science and new technology concepts to support national security.

Mr. Lemnios is a Principal member, Committee on Technology of the National Science and Technology Council; Advisor, Defense Acquisition Board; Chairman, Radiation Hardened Oversight Council (RHOC); Chairman, Defense Science and Technology Advisory Group (DSTAG); Chairman, Armed Services Biomedical Research Evaluation and Management Committee; Chairman, DoD Combat Feeding Research and Engineering Board (CFREB); and Chairman, DoD Biometrics Executive Committee.

Before assuming this position, Mr. Lemnios was the Chief Technology Officer of MIT Lincoln Laboratory, responsible for coordinating technology strategy across the organization and for establishing and growing external strategic relationships to support current and future Laboratory missions. He also served as Assistant Division Head of the MIT Lincoln Laboratory Solid State Division, as a member of the Laboratory's Senior Management Council and as the Co-Chair of the Laboratory's New Technology Initiative (NTI) Board.

Between 2002 and 2005, while at the Defense Advanced Research Projects Agency (DARPA), Mr. Lemnios was Director of the Microsystems Technology Office (MTO), and previous to that, the Deputy Director of the Information Processing Technology Office (IPTO). In these positions, he oversaw the development of future research thrusts, analyzed and evaluated program proposals and engagements with commercial, academic organizations and represented DARPA on various national committees.

Mr. Lemnios held various positions within industry at Hughes Aircraft Company, Westinghouse Electric Corporation and Ford Microelectronics, Inc. that led to the development and demonstration of advanced microelectronic components. He has served on numerous DoD, industry and academic committees.

Mr. Lemnios received his BSEE from the University of Michigan and his MSEE from Washington University in St. Louis. He has authored over 40 papers, holds 4 patents in advanced GaAs device and MMIC technology and is a Senior Member of the IEEE.

STATEMENT BY
DR. MARILYN FREEMAN
DEPUTY ASSISTANT SECRETARY OF THE ARMY
FOR RESEARCH AND TECHNOLOGY

BEFORE THE
SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITES
COMMITTEE ON ARMED SERVICES
UNITED STATES HOUSE OF REPRESENTATIVES

ON
THE UNITED STATES ARMY'S SCIENCE AND TECHNOLOGY (S&T)
PROGRAM FOR FISCAL YEAR 2012

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STATEMENT BY
DR. MARILYN FREEMAN
DEPUTY ASSISTANT SECRETARY OF THE ARMY
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Mr. Chairman and Members of the Subcommittee, thank you for having me here today to discuss the fiscal year (FY) 2012 Army Science and Technology (S&T) Program and the significant role we have in supporting the Warfighter while developing the technologies that drive our Army's transformation. We in the Army S&T community are grateful to the members of this Committee for your sustained support of our Soldiers especially in this time of war, and for funding the investments that will provide our future Soldiers with the technology to defend America's interests and those of our allies around the world.

I was appointed Deputy Assistant Secretary of the Army for Research and Technology in July of 2010, and this is my first time testifying before this subcommittee. I have spent my entire 30-year career in Army S&T, most recently as the Director of the Natick Soldier Research, Development and Engineering Center (NSRDEC). It is an honor to appear before the Subcommittee today.

Simply put, my mission is to reinvent Army S&T to foster invention, innovation, and demonstration of technologies for the current and future Warfighter. Soldiers are our decisive weapon, and in this environment of persistent conflict, we must be able to provide the technology enabled capabilities that Empower, Unburden and Protect the men and women who voluntarily put themselves in harm's way for our country and those things we as Americans hold dear. While Army S&T has been doing this for the past several years, it is time we step up our game, and focus on results that will get these capabilities to our Soldiers more quickly and affordably than ever before.

My experience has taught me that in order to best achieve success, Army S&T needs to be better focused, more accountable, and more transparent. I have already begun to use the lessons learned over the past ten years to reshape this organization to better serve the needs of the Soldier, and to ensure Army S&T is the "go-to" place for Army Senior Leadership on all S&T and engineering issues. Coming into this job, I set out nine strategic goals to help guide our success:

- Conduct "World Class" Science and Technology
- Affect timely transition of the right technologies
- Be the recognized leader in Defense Development and Engineering
- Form strong internal and external partnerships

- Maintain high-quality, relevant facilities and capabilities
- Develop and maintain a balanced investment portfolio
- Maintain a highly skilled, motivated workforce that exemplifies our core values
- Build effective, efficient and adaptable processes
- Foster government and public understanding of our value

Many of these goals are well on their way to being met, while others will require a reinvigorated, dedicated effort. Taken together, these goals will ensure that the Army's S&T program provides our Soldiers the world's most advanced capabilities both for the current fight and for the future.

One of the keys to our success, especially in this constrained budget environment, will be to effectively prioritize our programs in better synchronization with the needs of the Warfighter. In the coming months I will be working with the Senior Army Leadership, our partners in the U.S. Army Training and Doctrine Command (TRADOC), the Program Executive Offices and the S&T leaders, to develop a list of their top priorities to help us better focus our research and development efforts. This is less a matter of shifting investments – rather a shift to an alternative and more relevant program management approach.

With this approach in place, I believe the FY 2012 budget request we have submitted to the Congress will provide the correct levels of investment for our enterprise. Our S&T program request (6.1-6.3) for FY12 is $2.3 billion, a 15.8% increase over our FY11 request. This increase includes the assumption of the High Performance Computing Modernization Program and the Historically Black Colleges and Universities program, and increased investments for research on Soldier load, vehicle survivability, armor materials, and other areas. As we look at this budget, we must rethink the way we manage these investments for maximum accountability and transparency. As such, I have reorganized my office to allow for more holistic management and oversight across our lines. I am using a portfolio management approach to organize our investments. The four portfolios are Soldier, Air, Ground and Command, Control and Communications (C3). In addition, I have new responsibility for a small amount of 6.4 funding for competitive prototyping. This line will enable us to better meet the competitive prototyping requirements of the Weapons System Acquisition Reform Act (WSARA) and mature promising technology capabilities to a higher Technology Readiness Level (TRL) level within S&T. At this time, we are establishing a governance structure and an annual selection and review process to pick the most promising, relatively mature technologies or sub-systems for funding. These programs will be selected based on their potential to transition to a high priority Program of Record

(POR) and their potential to demonstrate a TRL of six or greater within one to two years. This initiative will establish a closer alignment between S&T and acquisition, and expedite our capability to transition technology enabled capabilities from the lab to operational use.

By looking at our enterprise in terms of these four portfolios, and not merely in terms of funding lines or Laboratories/Research, Development and Engineering Centers (RDECs), we are better able to synchronize our efforts across the S&T enterprise. Each of the four portfolios is managed as investments in: (1) far-term, basic research for discovery and understanding of phenomena; (2) mid-term, applied research for laboratory concept demonstrations; and (3) near-term, advanced technology development for demonstrations in relevant environments outside the laboratory. Each draws from complementary efforts in other portfolios, and each also benefits from the Army's investments in manufacturing technology.

Soldier

In keeping with a renewed commitment to making the Soldier the Decisive Weapon, the Soldier portfolio includes technologies for Soldier and Small Combat Unit lethality, protection, equipment, shelters, clothing, food, safety, training and medical technologies, as well as initiatives to address Soldier Power and to Lighten the Soldier's Load. In the coming years, improving mission performance in both a cognitive and physical sense will be one of the greatest challenges for the Army. This cuts across many areas of research, from the physical weight of equipment, to technology enabled capabilities to overcome information and sensory overload in an increasingly digital and networked environment, to Soldier knowledge, skills and training. In coordination with the C3 portfolio, we are looking at methods of ensuring that correct information is delivered to the correct Soldier or unit, without inundating them with non-critical data. This involves better understanding how individuals learn so information delivery systems can be tailored to specific human characteristics and the development of management algorithms that lower the cognitive burden on Soldiers. In the physical realm, we are investigating the trade-offs between the limits of human physical performance and the capabilities they will require in the field. This includes advanced mission planning technologies and training to allow Soldiers and units to better tailor necessary loads based on mission requirements. This will allow the future Soldier to maximize the potential of advances in off-loading, nutrition science and physical fitness, among other areas.

Another major area of effort in this portfolio is Post-Traumatic Stress Disorder (PTSD)/Traumatic Brain Injury (TBI). At least 20-40% of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) Soldiers report symptoms of PTSD. The effect of PTSD can be far-reaching and its symptoms often negatively impact a person's

mental and physical health, work and family relationships. Individuals with PTSD are six times more likely to attempt suicide. Due to the number and severity of explosive weapons, it is estimated that 12-20% of OIF/OEF veterans have possible TBI, which ranges from mild to severe. Although most OEF/OIF veterans experience mild TBIs (a loss of consciousness that lasts for 30 minutes or less, or a period of amnesia that lasts for less than 24 hours), some of these Soldiers may be diagnosed with PTSD, and are more susceptible to substance abuse, adjustment, and anxiety disorders.

At the U.S. Army Medical Research and Materiel Command (MRMC) we are conducting a wide variety of research to optimize and enhance Warfighter behavioral health, psychological resilience and diagnosis/treatment for blast-induced brain injury. Basic research is conducted to provide fundamental knowledge for biomedical solutions that protect Soldiers and enhance their performance in operational and training environments that include multiple internal and external stressors. Other fundamental research is conducted to understand the basic mechanisms of severe trauma in order to advance treatment and surgical procedures, and to develop experimental models to support in-depth trauma studies. MRMC is developing mechanisms for detection of physiological and psychological health problems, enhanced screening, diagnosis and treatment for mild TBI, PTSD, suicidal behavior and other psychological conditions. Efforts in FY12 will also mature and demonstrate a neuroprotective drug to treat TBI as well as a deployable diagnostic device to assess brain trauma in the field.

Ground

The Ground portfolio includes technologies for manned and unmanned ground platforms and mobility systems, ground-based sensors and weapons systems, active and passive protection systems and deployable small base protection.

We are very concerned about the serious injuries and loss of life inflicted on our Soldiers in all types of ground vehicles by Improvised Explosive Devices (IEDs). Recognizing this, for FY12 we have developed a concerted effort in Underbody Blast (UBB) Protection. We currently possess a limited capability to predict blast injury to vehicles and personnel with enough fidelity and robustness to improve existing and future blast protection technology. As a result, we are looking at the entire blast kill chain comprised of the energetic event, system response, occupant response and injury, and platform and component interaction to design solutions for this critical problem.

To this end, we are focusing on three areas of research: Modeling and Simulation (M&S) activities, physiological effects, and development of a representative test dummy. M&S activities take advantage of the wide range of expertise across the S&T enterprise. At NSRDEC we are increasing the fundamental understanding of blast effects on

humans and personal protective equipment, validating range of motion measurements with operationally-relevant assessment techniques for body armor, and analyzing data to optimize protection concepts and advance state-of-the-art design rules for individual armor. The Tank Automotive Research, Development and Engineering Center (TARDEC) is addressing model information gaps that include sensitivity of the elements of the blast kill chain, human effects and injury modeling, and blast injury mechanisms. TARDEC is also increasing fidelity in end-to-end M&S tools for occupant protection and vehicle underbody and Soldier blast protection. The Army Research Lab (ARL) is incorporating energy absorbing seats and local soil characteristics into models of full-scale blast events, and the Simulation and Training Technology Center (STTC) is quantifying models for deviations in vehicle structural materials.

MRMC is initiating physiological research to develop UBB human tolerance limits and injury prediction tools for blast injury prevention standards to use in survivability assessments and protection systems development as well as evaluating hazards to head, neck, spine, eyes, and ears, and the standards for rapid return-to-duty.

Finally, the Warrior Injury Assessment Manikin (WIAMAN) effort is creating a Warrior-representative test dummy and associated injury assessment tools for use in live-fire test and evaluation and vehicle development efforts.

Another key concern is preventing and defending from assaults on small bases, such as the attack near Wanat, Afghanistan in July 2008. In FY12, we are continuing to make key investments in Deployable Force Protection (DFP) to provide capabilities to deployed troops operating in smaller, expeditionary bases (less than 300 persons), particularly at outposts or those bases more integrated within local communities, but with a less overt security posture. Solutions drive toward resilient, low-logistics, lightweight, easily transportable, minimal manpower products that readily scale and integrate with other base defense systems. A key part of this effort is adaptive red teaming experiments. These are conducted to develop a more thorough understanding up-front and throughout the fielding process of the defeat mechanism for systems - what can be overcome or mitigated by engineering and what can be mitigated by tactics, techniques and procedures (TTP). Technologies include, but are not limited to, sensors, blast and ballistic materials, remotely operated and precision active protection systems, communications, denial and deception, and enablers to achieve situational awareness and understanding. This holistic approach to DFP allows us to leverage the expertise of a wide variety of our labs and centers, as well as S&T efforts throughout the Services and OSD.

These ongoing DFP efforts have already paid off. The Small-base Leader Entry Control Point (ECP) Guide was completed in August 2010 as a 90-day Quick Reaction Fund Initiative to provide a practical guide for planning, design, construction and operation of

entry control point locations at small bases. This tool provides guidance to the small-base leader to enable him in constructing and operating an ECP that will reduce casualties at these highly vulnerable locations. This product is top rated 4-stars by over 300 Army Training Network Users and has been described as a favored document for training by deploying units at the Center for Army Lessons Learned. Beyond our current successes in this area, we still have much more to do. Our program provides focus on making these contingency base camps not only safer but more effective and efficient in supporting our Soldiers' mission.

Air

The Air portfolio is focused on five broad areas of research: platform technology; operations and support; survivability; rotors and flight controls; and unmanned systems. 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.

In order to provide Soldier support over future Areas of Operation (AO) sixteen 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 6000 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. A major platform development effort currently underway within S&T is technology development for the Department of Defense's next potential clean sheet design rotorcraft, the Joint Multi-Role (JMR) aircraft. S&T will lead the way in the development of innovative vertical lift technologies that provide significant improvements in speed, range, survivability, and operational costs. The JMR program goal is to develop and integrate these technologies into two technology flight demonstrators, or X-planes, that provide transformational operational capabilities, while also improving operating efficiencies, and platform survivability.

Reduced cost of ownership is a critical aspect of any new weapon system, and this is particularly true for aviation systems. While helicopter operations have been uniformly praised by combatant commanders in Afghanistan and Iraq as one of the critical nodes of successful counterinsurgency operations, their high availability rates under the stressing optempo of the last several years has come at a cost. Significant maintenance augmentation by contractor teams has been the key to maintaining flight readiness rates. The good news is that data from these deployed units is being used today to better understand wear and failure mechanisms in our complex aircraft systems, operating in stressing environments. We have made great strides in mechanical sensing, diagnostics, and prognostics to enable reduced unnecessary maintenance actions and improved anticipation of imminent part failure before accidents

occur. We also have investigated innovative composite materials and fabrication techniques that optimize load distribution and stress alleviation. All of these technologies will be incorporated into the JMR program to demonstrate transformational performance at an affordable cost of ownership.

C3

The key to successful operations in an increasingly complex battle space is the capability for seamless and timely communications across all echelons of the system, from headquarters to the Soldier on the ground and in vehicles. Within the C3 portfolio we are working to define and develop the next generation communication and networking capabilities.

One current effort in the C3 portfolio is the Multi-Access Cellular Extension (MACE), a program that inserts commercial-off-the-shelf smartphone technologies from multiple vendors into the tactical environment, applies appropriate security measures, and integrates them into military network operations management capabilities. This will allow Soldiers to take advantage of the flexibility and ease-of-use of these devices, operating seamlessly in a mixed WiFi/cellular environment. One benefit of smartphone technology is bundling functionalities, such as voice, data, military-purposed smartphone applications, and position/location information into a single device to save weight, space, and power. Another benefit of this approach is to unburden Soldiers and simplify their training by providing them with tools and interfaces that many of them are already familiar with. MACE also seeks to improve Soldier position/location understanding by augmenting the GPS in smartphones with radio frequency ranging to better adapt to GPS-challenged urban environments and complex terrain.

The MACE program explores smartphones operating through a cellular base station that is connected to a military network such as the Warfighter Information Network – Tactical (WIN-T. This allows Soldiers to take full advantage of the mixed WiFi/cellular capabilities of the smartphone while maintaining interoperability with the military network. The WiFi mesh networking application will allow groups of Soldiers with smartphones to automatically form into a local network when they are not able to connect to a cellular base station or WiFi hot spot on the military network, and then reconnect to the larger network when they come back within range. This will allow dismounted Soldiers to remain connected with each other when they lose connectivity with the tactical networks.

The C3 portfolio also looks to fully leverage multifunction assets that are networked, and can be programmed/tasked to support whatever pillar of Electronic Warfare (EW) that needs additional assistance; Detection, Identification, Threat Mapping, Electronic Jamming, etc. This networking capability will be based on an integrated and distributed

EW framework and should lead to the effective management and coordination of friendly Electromagnetic dependent systems while countering & exploiting adversary systems. These efforts provide direct support to the Soldier, Air and Ground portfolios, and will provide an unprecedented capability to shape the electromagnetic battle space in our favor.

Underpinning all of our efforts is a strong basic research program, which is essential to realizing superior technology enabled capabilities. The search for new fundamental knowledge through high-risk/high-payoff basic research is very important to me and to our highly skilled scientific workforce. My goal in this area is to ensure that the Army Basic Research program is of extremely high quality and is focused in areas that provide the foundation for a broad range of potential applications or technology enabled capabilities, with a specific eye on relevance to the Soldier and to the Army mission. To accomplish these goals the Army maintains a robust basic research effort that extends across a variety of disciplines, leveraging some of the best minds in the country.

For FY12, we will continue to enhance our investments in robust research in materials modeling efforts across scales – from the molecular/atomistic to the material system level – to create materials with new or enhanced structural, electronic, chemical, biochemical, or energetic properties. This effort will be conducted both in-house and with our extramural partners in academia and industry and will lead to new methods and materials for a broad range of potential applications across the Army including lightening our Soldiers load and providing new capabilities for force protection for Soldiers, platforms and facilities.

President Obama has continued to put forth the need for increased national attention to building our capabilities in the fundamental sciences to ensure our nation remains a global leader in technology. The Army as well continues strong support for university research and research education of students through its competitive single investigator program. Single investigator investments will lead to fundamental discoveries in areas such as electronics, quantum imaging, mechanical chemistry, brain-electronics interfaces, bio-forensics, and harnessing bacteria for micro-scale manipulation of materials, while educating the next generation of scientists, engineers and mathematicians and familiarizing them with the Army's research community.

I also believe in the importance of engaging with smaller companies doing innovative research outside of the realm of the traditional defense industry. The Army Small Business Innovation Research (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. We work hard to ensure that these efforts complement our programs and provide direct value to our Soldiers. Each year, the Army SBIR office allocates over 200 topics to the laboratories, TRADOC and the

program executive offices that are based on Army requirements. In response to these topics, small businesses submit over 3000 proposals each year, which are evaluated by the Army SBIR office and which result in more than 600 Phase I and Phase II awards to the small businesses valued at approximately $250M.

Many of these Phase II SBIR projects move up to Phase III SBIR, Phase II enhancements, or the Commercialization Pilot Program (CPP) on their way to becoming a part of an Army program of record. A recent example of one such program is a small electronic device that increases the flow of blood to the brain and heart to treat traumatic brain injury. It received CPP money and has begun field integration. Another SBIR company has developed a way to attach biocides to textiles and equipment surfaces to make self-decontaminating uniforms as well as coatings for vehicles and equipment for use against biological agents. This has also moved to Phase III SBIR and has received $3.4M from several DoD programs. A third Army SBIR company developed a new, durable, ceramic composite tile for Soldier body armor that is low cost, low weight, and high performance. To date, over 250,000 tiles have been sold for use by Soldiers and Marines. Army SBIR is a dynamic and active program that is promoting the power of small business to meet Army needs

Of course, none of our efforts would be possible without a solid infrastructure and workforce. To maintain technological superiority now and in the future, the Army must continue to hire top quality scientists and engineers into the Army Laboratories and Centers. We continue to work to attract and retain the best science and engineering talent. 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. 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.

I am greatly concerned with the health and long-term viability of our labs. We have long worked to make improvements at the margins, and where possible we have used the Defense Base Closure and Realignment (BRAC) Commission process to modernize facilities and infrastructure. This is not a long-term solution, and I intend to take an in-depth look and assess what needs to be done to truly maintain world-class facilities. With the support of the Committee, our labs and centers are now able to spend a portion of their funding on minor military construction projects. While this authority has been helpful, this will continue to be one of our major challenges in the years to come.

As I mentioned earlier, for FY12 the High Performance Computing Modernization Program (HPCMP) and office will transition from the Office of the Secretary of Defense (OSD) to my office for management and funding. The U.S. Army Corps of Engineers currently manages a large portion of the program, so it makes sense for them to

manage the entire portfolio. HPCMP is and will remain a tri-service and agency program managed by the Army. Plans and discussions are underway between OSD and the Army in order to ensure a smooth transition. The HPCMP supports a network of supercomputing centers that provide high performance computers, scientific and engineering software, and expertise to DOD scientists and engineers, and has three main components: Operating six DOD Shared Resource Centers, operating and maintaining the Defense Research and Engineering Network, and Software Application Development. DOD scientists and engineers use HPCMP resources in support of many disciplines, including physics, chemistry, materials, acoustics, and aerodynamics. The Army, with the Services and OSD, is fully committed to managing and executing this effort.

First and foremost, I am a teacher by training. I strongly believe we have an obligation to educate our young people in all disciplines to ensure their future success, and the success of our country. In particular, I believe that strong science, engineering and mathematics education at all grade levels and from a diverse population is critical to both the ongoing success of the Army S&T enterprise and the nation as a whole. In FY12, the Army has been assigned the responsibility to execute the DOD program to manage and increase the research capacity of Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) and the training of minority students in Science, Technology, Engineering, and Mathematics (STEM) disciplines. In order to ensure the continued success of DOD's HBCU/MI program, the Army is and will be an active member in the DOD HBCU/MI Program Advisory Group, providing guidance and promoting opportunities for these valuable students to excel. Additionally, Army S&T contributes to the future success in STEM through the Army Educational Outreach Program (AEOP) which comprises 17 outreach efforts, either through direct oversight or through active participation. In the 2009-2010 academic year AEOP received over 12,797 student online applications, engaged nearly 85,000 students as well as 198 teachers, involved 199 universities and utilized the experience and personal commitment many of our Army scientists and engineers. An instrumental initiative that is expected to have the single biggest impact on how the programs run is the Army's Education Cooperative Outreach Agreement (COA) which was awarded in FY11. The Educational COA will bring together government and a consortium of organizations working collaboratively to further STEM education and outreach efforts nationwide. An additional thrust is the enhancement of the online, comprehensive application tool located on the AEOP website. 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 FY12, we are concentrating on ways to

expand the reach and influence of successful existing programs by leveraging partnerships and resources with other services, agencies, industry and academia.

These are exciting and challenging times for the Army's S&T program. We need to continue the support we've provided to the current and future force, while adapting our culture to become better focused, more accountable, and more transparent. We need to do all this in a time of budget constraint. I am confident that our programs and most importantly our people can rise to the challenge and ensure that the Soldier is the Decisive Weapon. I would like to thank the members of the Committee again for all you do for our Soldiers, and would be happy to take any questions you have.

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Deputy Assistant Secretary for Research & Technology (SAAL-ZT)

Dr. Marilyn Miller Freeman

Dr. Marilyn M. Freeman was designated as the Deputy Assistant Secretary for Research and Technology in July 2010. Dr. Freeman is responsible for the entirety of the Army's Research and Technology program, spanning 21 Laboratories and Research, Development and Engineering Centers, with more than 10,000 scientists and engineers and a yearly budget of nearly $2 billion dedicated to empowering, unburdening and protecting Soldiers. Previously, Dr. Freeman served as the Director of the US Army Natick Soldier Research, Development and Engineering Center.

CAREER CHRONOLOGY:

- Sep 2007 –Jul 2010 Director of the US Army Natick Soldier Research, Development and Engineering Center.
- Sep 2007 –Selected to the Senior Executive Service ; appointed to the position as the Director of the US Army Natick Soldier Research, Development and Engineering Center.
- Oct 2006 – Sep 2007: Deputy for Technologies, Office of the Deputy Assistant Secretary of the Army for Research and Technology, Washington, DC
- Oct 2005 – Sep 2006: Technical Director (Acting), US Army Tank Automotive Research, Development and Engineering Center, Warren, MI
- Oct 2001 – Sep 2005: Deputy for Armament, Vehicle and Soldier Technologies, Office of the Deputy Assistant Secretary of the Army for Research and Technology, Washington, DC
- May 2001 – Sep 2001: Technical Director, Future Combat Systems, Defense Advanced Research Projects Agency, Arlington, VA
- Sep 1998 – Apr 2001: Program Manager, Combat Hybrid Systems Program, Defense Advanced Research Projects Agency, Arlington, VA
- Oct 1997 – Aug 1998: Special Assistant to Associate Director for Technology, Army Research Laboratory, Adelphi, MD
- Aug 1996 – Sep 1997: Liaison, Office of the Director of Research, Office of the Deputy Assistant Secretary of the Army for Research and Technology, Washington, DC
- Aug 1990 – Jul 1996: Army Liaison, Electric Armaments Program, University of Texas at Austin, TX
- Apr 1981 – Jul 1990: Senior Scientist, US Army Armaments Research, Development and Engineering Center, Picatinny Arsenal, NJ

EDUCATION:

- PhD, Materials Science and Engineering, The University of Texas at Austin, Austin, TX, 1996
- MS, Materials Science, Stevens Institute of Technology, Hoboken, NJ, 1990
- BS, Physical Science, University of Dayton, Dayton, OH, 1975

CERTIFICATIONS:

- Level III, Army Acquisition Corps, Systems Planning, Research, Development and Engineering

PROFESSIONAL MEMBERSHIPS AND ASSOCIATIONS:

- Association of the United States Army

MAJOR PUBLICATIONS:

- Dissertation, Effect of Defects on Breakdown of Dielectric Materials, 1996

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HOUSE ARMED SERVICES COMMITTEE
EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

STATEMENT OF
REAR ADMIRAL NEVIN P. CARR, JR., UNITED STATES NAVY
CHIEF OF NAVAL RESEARCH

BEFORE THE
EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE
OF THE
HOUSE ARMED SERVICES COMMITTEE
ON
THE FISCAL YEAR 2012 BUDGET REQUEST

MARCH 1, 2011

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EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

Introduction

It is an honor to appear before you to report on Science and Technology (S&T) efforts within the Department of the Navy and discuss how the President's FY 2012 Budget supports the Navy and Marine Corps. The President's FY 2012 Budget requests $2 billion for Naval S&T.

The Naval S&T objective is to support a Navy and Marine Corps capable of prevailing in any threat environment. The Office of Naval Research (ONR) continues to work directly with the Secretary of the Navy (SECNAV), Chief of Naval Operations (CNO) and Commandant of the Marine Corps (CMC) to address critical challenges by: 1) focusing on S&T areas that provide the biggest payoff for the future, 2) encouraging innovative thinking and business processes, and 3) continuing to assess results and improve transition of S&T into acquisition programs.

We are efficient at what we do, and well-guided in future spending to strike a balance between responsive near term technology insertion and unfettered, innovative long-term basic research. It is the latter category that holds greatest potential for true game-changers such as the Global Positioning System (GPS), Autonomous Vehicles, the Free Electron Laser (FEL), and the Electromagnetic Railgun. There are many Navy S&T products in the Fleet/Force today with many more on the way. Among our greatest challenges are meeting SECNAV's Science, Technology, Engineering and Mathematics (STEM) goals, shaping and building an even higher quality S&T workforce, and recapitalizing the Naval Research Laboratory (NRL) infrastructure.

Our first task is to support the SECNAV's priorities: 1) taking care of Sailors, Marines, Civilians and their families, 2) treating Navy energy requirements and solutions as issues of national security, 3) creating acquisition excellence, and 4) optimizing unmanned systems. The next step involves both CNO priorities and CMC guidance. We have to build the future force, maintain warfighting readiness, and develop and support the entire Navy/Marine Corps family, uniformed and civilian. Where Marines are concerned, this involves training and equipping them for Afghanistan, rebalancing the Marine Corps (USMC) of the future through better education and training, and never forgetting to keep faith with service personnel and families. Each of these objectives demands the application of S&T resources. In addition to our focus on areas that provide the big payoff, innovative thinking, and improving our ability to transition S&T, we must improve strategic communication and engagement with stakeholders. We are getting better at this every day, but can never afford to rest on our laurels.

Science and Technology Strategic Plan

The Naval Science and Technology Strategic Plan was developed to guide our S&T investments. The Naval S&T Strategic Plan is regularly reviewed by Navy and USMC leadership to reaffirm alignment of Naval S&T with current Naval missions and future capability needs. It ensures S&T has long-term focus, meets near-term requirements, and makes our course clear to decision makers, S&T partners, customers and performers.

The S&T Plan identifies thirteen focus areas where S&T investment will have high payoff supporting Navy and USMC requirements: 1) Power & Energy, 2) Maritime Domain Awareness, 3) Operational Environments, 4) Asymmetric and Irregular Warfare, 5) Information

Superiority and Communication, 6) Power Projection, 7) Assure Access and Hold at Risk, 8) Distributed Operations, 9) Naval Warfighter Performance, 10) Survivability and Self-Defense, 11) Platform Mobility, 12) Fleet/Force Sustainment, and 13) Total Ownership Cost.

In each area, our goal is to move from existing systems and concepts of operations toward a warfighting capability to counter predicted threats in an increasingly complex and uncertain environment. While the starting point is continued evolution of current systems, we progress toward incremental improvements and spiral development, to new development of known technologies, and finally to new development of undiscovered disruptive technologies. If we are good, and perhaps lucky, this is where today's S&T encounters the unanticipated future. At its best, that is what S&T is all about.

Executing the Strategy

We execute Basic Research (6.1) thru Advanced Technology Development (6.3) funds by dividing S&T into three primary areas – Discovery and Invention (D&I), Innovative Naval Prototypes (INP), and Future Naval Capabilities (FNC). In addition, we maintain Rapid Reaction capability to respond to respond to emerging emergency requirements.

Discovery and Invention

Discovery and Invention (D&I) includes basic research (6.1) and early applied research (6.2) in areas with unique requirements essential to the Naval mission, but also in areas that are undefined but hold promise for future application. This is the nature and the power of Basic Research. D&I develops fundamental knowledge, provides the basis for future Navy/Marine Corps systems, and sustains our Scientist and Engineer workforce. Research areas of emphasis include autonomous sciences, bio-inspired sciences, cognitive/neural training technologies, information technology, advanced quantum computing, materials sciences (metamaterials, integrated computational material sciences, nano-manufacturing), and counter Improvised Explosive Device (IED) sciences.

Approximately 40 percent of S&T investment is in D&I. We assess impact on Navy/Marine Corps missions, as well as potential for innovative performance, in order to invest resources in the best research areas and projects. This develops a broad base of scientific knowledge from which INP, FNC, and quick reaction efforts are generated. Approximately 60 percent of basic research is executed with academic and non-profit performers, with all programs peer reviewed during the second to third year from inception to ensure high quality and integrity.

An important element of D&I is the Defense University Research Instrumentation Program (DURIP), which supports university research essential to Naval research. DURIP complements our D&I programs by supporting purchase of high cost instrumentation necessary to carry out cutting-edge research. ONR awarded 68 DURIP grants in FY 2007, 92 in FY 2008, 82 in FY 2009, 61 in FY 2010, and plans to award approximately 60 grants in FY 2011. Another D&I program, ONR's Basic Research Challenge, stimulates interdisciplinary research in emerging S&T fields by funding promising research in areas not addressed by the current basic program.

D&I investments develop and sustain the S&T workforce and support Science, Technology, Engineering and Mathematics (STEM) outreach. Through Independent Laboratory In-house Research (ILIR) and Independent Applied Research (IAR) programs, ONR sponsors critical research, while furthering education of scientists and engineers at Warfare Centers. Education and research opportunities for undergraduate and graduate students, fellows, and future faculty members and researchers are provided through programs such as the Naval Research Enterprise Internship Program (NREIP), which expose participants to work at Naval laboratories.

Through the University Research Initiative (URI) and Young Investigators Program (YIP), ONR gains access to researchers with a willingness to investigate high priority topics of interest to the Naval services. Through our Multidisciplinary University Research Initiative (MURI), ONR supports multi-disciplinary university teams to speed scientific progress by cross-fertilization of ideas, hasten transition of basic research to practical applications, and train students in cross-disciplinary approaches to science and engineering research of importance to DoD. We actively support Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) with research and education partnerships. We also support the Presidential Early Career Award for Scientists and Engineers (PECASE), honoring achievements of young professionals at the outset of independent research careers in S&T. Through demonstration, apprentice, award, and graduate programs, we encourage young people to explore S&T careers in academia, Naval labs, and industry.

ONR supports research at the Department of the Navy's corporate lab, the Naval Research Laboratory (NRL). This support, known as the NRL base program, develops S&T to meet needs identified in the Naval S&T Strategic Plan, and sustains world class skills and innovation in our in-house laboratory.

Science, Technology, Engineering and Mathematics (STEM)

In late 2009, ONR was tasked with coordinating all Naval STEM educational and outreach activities. Through this STEM education and outreach effort, the Navy is making critical contributions aimed at strengthening America's competitive edge, and ensuring a sufficient talent pool exists to support future Naval technical needs. These professionals are a key to innovation, which is critical to maintaining U.S. economic competitiveness and the Navy's S&T strength.

As you know, the production of STEM graduates in the U.S. is not keeping up with either the U.S. demand or international competition. Yet only fifteen percent of bachelor's degrees earned by U.S. students are in STEM fields. Additionally, if one looks at the breakdown of students receiving STEM degrees, the number of underrepresented minorities and women does not reflect the demographics of our nation. Given that we expect a shortage in STEM fields in the future, these trends need to be attacked now. Additionally, these trends are countered by STEM growth in countries like China and India, with obvious implications for our long term security.

The purpose of the Navy's STEM program is to help reverse these negative trends and ensure a base for a strong, STEM literate Naval workforce in the future. ONR/NRL investments represent nearly 70% of the overall Naval services investments in STEM. The Secretary of the Navy committed to doubling the Navy's investments in STEM over the next five years,

compared with FY 2010. Our investments seek to increase the diversity and numbers of students pursuing STEM degrees and encourage collaboration among the government and best practice organizations, universities and industry. Our areas of emphasis include: 1) freshman and sophomore retention; 2) middle school, hands-on STEM learning programs in urban and rural settings; 3) teacher training; and 4) advanced Ph.D. and post-doctoral support. Perhaps most importantly, our newest programs incorporate both Naval relevant content and metrics for measuring impact and will have to be coordinated, for maximum impact, with other Federal STEM education programs.. Further, these programs were selected based on their potential for rapid growth and geographic expansion.

Innovative Naval Prototypes

Innovative Naval Prototypes (INP) involve 10 percent of the S&T budget and focus on high-risk/high-payoff opportunities emerging from the D&I portfolio that can significantly impact Naval capabilities if we can mature the technology. INPs are discontinuous, disruptive, radical departures from established requirements and operational concepts. Approved and overseen by the Naval S&T Corporate Board (Assistant Secretary of the Navy for Research, Development and Acquisition (RD&A), Assistant Commandant of the Marine Corps and Vice Chief of Naval Operations), the goal is to prove concepts and mature technology within 4-8 years, allowing informed decisions about risk reduction and transition into acquisition programs.

We have seven current INPs:

The Free Electron Laser (FEL) INP will bring laser technology to sea for ship offense and defense against a variety of threats. The FEL will develop a laser that is dynamically tunable to atmosphere-penetrating wavelengths for use in maritime environments. This will allow us to assess the potential of Megawatt class laser-based shipboard defense that includes tracking, discrimination, countermeasures, and scalable direct fire at the speed of light. The FEL is designed to defend against current and future surface and air threats, anti-ship cruise missiles, small boat swarms, and other asymmetric threats.

The Integrated Topside INP will enable Navy to dominate the electromagnetic spectrum through development of multifunction apertures for all ship classes. We are developing: 1) open architecture for Radio Frequency (RF) equipment, plus computer hardware and software that will enable industry to contribute to development of affordable new systems and upgrades, and 2) modular systems that enable the same technology to be scalable across all Naval platforms to significantly reduce logistics, training, and maintenance costs.

The Electromagnetic Rail Gun (EMRG) INP continues to develop and test a scalable, more powerful gun, using non-explosive rounds with no gun propellant. The EMRG has more than doubled current state of the art muzzle energy. The program continues to achieve a limited set of technical objectives while initiating Phase Two of the program. EMRG will provide multi-mission capability for long range, persistent, precision fire without unexploded ordnance issues, while increasing magazine capacity, and decreasing total cost. If current research goes as hoped, Projectiles will eventually fire at a muzzle velocity of Mach 7.5 and reach targets 200+ nautical miles away in less than six minutes, impacting at a velocity exceeding Mach 5. In addition to

Naval surface fire support, Navy is examining lower power, accelerated opportunities for Anti-Surface Warfare and self defense applications with nearer term capability against cruise missiles and other challenging targets. Contractors have built and tested pre-prototype tactical launchers. I invite all of you to schedule a visit to our test bed facility at the Naval Surface Warfare Center at Dahlgren, Virginia and am grateful to your staff members who have already made the visit.

The Large Diameter Unmanned Undersea Vehicle (LDUUV) INP is developing a reliable, long endurance UUV capable of extended operation in cluttered littoral environments. The program will develop the needed energy, autonomy and core UUV systems to operate in a complex ocean environment near harbors, shore, and high surface traffic locations. Key goals include doubling current UUV energy density, and using open architecture to lower costs, while enabling full autonomy in over the horizon operations. Achieving these goals will reduce Naval platform vulnerability, while enhancing warfighter capability and capacity gaps in critical mission areas.

The Autonomous Aerial Cargo/Utility System (AACUS) INP is working to develop intelligent, autonomous capabilities for an aerial cargo/utility system that can provide timely, affordable, reliable shipboard-compatible supply and retrograde. Our challenges include dynamic mission management en-route and using unprepared landing zones under demanding conditions. Potential solutions involve modular capabilities developed on open system architecture, novel human interfaces (to include optional manning), low impact (size, weight, power, and cost) sensors, and multiple flight demonstration and upgrade cycles.

The Persistent Littoral Undersea Surveillance (PLUS) INP is developing an autonomous over-the-horizon Anti-Submarine Warfare (ASW) system that removes humans and manned platforms for detection, location, classification and tracking of submarines. The PLUS INP demonstrates the utility of clandestine unmanned undersea vehicles employing ASW sensors with flexible deployment capabilities. The PLUS INP also provides a number of other technologies that expand our understanding of autonomous operations and help hasten this future capability.

The Sea Base Enablers INP selected three Transformation Craft (T-Craft) concepts for tests to characterize relative motion between vessels, evaluate ramp excursions, and quantify force and structural loads. Results were correlated with computer prediction models, and provided to the design teams for incorporation into technology development. We are completing the program with prototype construction and demonstration of key technology components in FY 2012.

Future Naval Capabilities

Our Future Naval Capability (FNC) program is the most critical component of our transition strategy. FNC investments align the "requirements-driven, transition-oriented" portion of the S&T portfolio to Naval Capability Gaps identified by the Office of the Chief of Naval Operations (OPNAV) and Marine Corps Combat Development Command (MCCDC). FNCs are near-term projects in the 30 percent of our budget focused on Acquisition Enablers. The FNC process delivers mature technologies to acquisition sponsors for incorporation into systems that provide new capabilities to the warfighter.

FNCs are based on earlier D&I investments, where technology has matured to the point that it can achieve a Technology Readiness Level (TRL) of 6 or better within 3-5 years. FNC projects are selected annually to address specific capability gap needs, with final prioritization approved by a 3-Star Technology Oversight Group (TOG) representing OPNAV, United States Marine Corps (USMC), U.S. Fleet Forces Command (USFF), Assistant Secretary of the Navy (ASN-RDA) and ONR.

Approved technology products are required to have Technology Transition Agreements that document the commitment of the resource sponsor, acquisition program, and ONR to develop, deliver and integrate products into new or upgraded systems to be delivered to the Fleet/Force. Every FNC product's progress and status is reviewed annually. Products that no longer have viable transition paths are terminated with residual funding used to solve unexpected problems with existing projects, or start new projects in compliance with Navy priorities.

The measure of FNC success is whether projects meet technology requirements and exit criteria, and whether acquisition sponsors have transition funds in their programs to accept and integrate FNC products. Products with planned transition funds usually transition after risks are mitigated, a definitive plan finalized, and required funding programmed.

Increases and Decreases in FNC Funding

As I stated last year, FNC investments focus on the most pressing capability gaps, generating year-to-year changes in funding for related Program Elements (PEs). As FNC products mature, Technology Readiness Levels (TRL) change, moving products from 6.2 to 6.3 PEs. Year one is predominantly 6.2; the final year predominantly 6.3 – with a mix of 6.2/6.3 in-between. When products transition to Advanced Component Development and Prototypes (6.4) and Engineering and Manufacturing Development (6.5) funding, new FNC products do not always begin in the same PE as those completed. While resulting changes may appear to be program growth, they actually reflect realignment of funds in response to successful transitions – coupled with reprioritization and new starts based on evolving Naval needs and requirements.

S&T Highlights

The Naval S&T portfolio includes a range of projects entering the Fleet/Force or about to enter in a short time. Following are examples of these efforts outlining the impact they will have on Sailors and Marines, today and in the future.

Power and Energy

ONR continues to invest in advanced technologies to boost platform power for improved warfighter capability and to increase energy efficiency to enhance platform endurance and reduce warfighter dependence on fossil fuels. Our S&T focus is on technologies and system architectures that increase both power density and energy efficiency. These efforts directly support the Navy's energy strategy and SECNAV's energy goals of sailing a Green Fleet in 2016 and increasing Department of the Navy (DoN) energy consumption from alternative sources.

Defense Department energy security requirements are driven by a variety of factors: 1) U.S. oil sources may not be stable, 2) price volatility impacts, 3) modern military systems use of energy is increasing, and 4) the logistics of moving fuel can limit combat operations and put warfighter lives at risk. Anyone watching recent news reports has a heightened awareness of each of these factors. In addition, there exist ongoing concerns about international economic manipulation, unexpected energy requirements associated with humanitarian relief, energy requirements associated with future systems, grid vulnerability, and climate instability. These are not new issues and have been studied by the Navy and Defense Department in a systematic fashion throughout the past decade.

ONR's role in energy technologies is to support unique Naval research, leverage government and commercial R&D investments, support workforce development in energy technology areas to meet unique Naval requirements, support test bed evaluations, and be an early adopter of technologies for shore facilities and platforms. These unique Naval areas include fuel, power generation, energy storage, energy distribution and control, and power loads for ships, aircraft, unmanned vehicles and expeditionary systems.

As just one example of practical implementation of our efforts, just over a year ago, Secretary of the Navy Mabus and Secretary of Agriculture Vilsack signed a Memorandum of Understanding between the Department of the Navy and Department of Agriculture with respect to development of advanced bio-fuels and other renewable energy systems. These include wind, solar, hydrokinetic, ocean thermal, and geothermal for electricity generation, and land for energy crops that can be refined into bio-fuels to meet both military and commercial transportation needs. In support of the MoU, ONR established a joint research program with the Agricultural Research Service to look at biomass sustainability with initial work focused in Hawaii.

Our objective is to accelerate the adoption of bio-fuels and blended logistic fuels by supporting Navy certification processes, and understanding and mitigating the impact of emerging fuels on Naval power systems and operations. To achieve these goals, we have invested in research about engine performance, materials compatibility, fuel stability, and bio-fuels and renewable energy.

In partnership with the Defense Advanced Research Projects Agency (DARPA), and the Electric Ship Research and Development Consortium (Florida State University, Massachusetts Institute of Technology, Mississippi State University, Purdue University, University of South Carolina, University of Texas at Austin, U.S. Naval Academy and others), we are moving toward the Navy's All Electric Ship. These programs include development of ONR systems such as EM Railgun and Free Electron Lasers, partnership with DARPA in Silicon Carbide Wide Band-Gap Power Electronics research, and Consortium efforts to develop advanced power concepts and new test and evaluation tools with emphasis on Naval applications.

We are exploring affordable long-endurance fuel cell power, with low noise and heat signature, to meet extended range mission requirements for unmanned air vehicles. We are also exploring advanced platform designs, launch and recovery, and autonomous operation of unmanned sea (surface) vehicles, as well as air independent power systems and lithium-ion battery safety for unmanned undersea vehicles. In addition, ONR is working to develop aviation propulsion and turbine engine technologies to identify and mature critical, relevant variable/adaptive cycle

system technologies for the next generation of carrier-based aircraft, while ensuring affordability and operational readiness.

Operations in Afghanistan forced the Marine Corps to reevaluate energy distribution and use in expeditionary environments. Marines operate over long distances in austere environments, and we are actively pursuing a wide range of ways to address the challenges of providing them with energy when and where they need it. These include lessening energy consumption and dependence on fossil fuels, while achieving resource self-sufficiency. S&T efforts focus on energy requirements of individual Marines, small dispersed units, and the tactical vehicle fleet. Investments in battery technologies, portable power generation, advanced power generation from JP-8 fuel, and renewable energy from solar power, combined with technologies that reduce fuel consumption, allow greater mobility and on-board power for tactical vehicles. These projects significantly reduced energy consumption and usage in expeditionary environments. A notable example is the Ground Renewable Expeditionary Energy System (GREENS) being used in Afghanistan where platoon level bases are powered solely via solar power. Ongoing additional evaluation of non-tactical hydrogen-powered General Motors fuel cell vehicles is occurring at Camp Pendleton and being expanded to Marine Corps Base Hawaii at Kaneohe Bay, in coordination with the other services and the Department of Energy.

Additional research developed the widely used Navy Reverse Osmosis Advanced Research Shipboard Desalination System, as well as the Expeditionary Unit Water Purification (EUWP) system. Developed for USMC expeditionary operations, EUWP was used in the aftermath of Hurricane Katrina at the Biloxi regional hospital and Port of Pascagoula, by the U.S. Coast Guard Station at Port Clarence, Alaska, and on the Macah Indian Reservation at Neah Bay, Washington. ONR also developed a Plasma Arc Waste Destruction System (PAWDS) for the new generation of aircraft carriers that is now being used by cruise lines, and the Micro Auto Gasification System (MAGS) for use in USMC expeditionary operations.

Some of the research in installation energy demand is dedicated to adopting energy efficient structural design practices, and designing energy neutral or low energy structures to simplify incorporation of alternative energy systems – such as at Ilima Middle School on Oahu. Advanced structural concepts provide low cost, energy efficient facilities that are easy to install – and can be *energy positive* by exporting power to a grid. In partnership with the Naval Facilities Command, Hawaii is also the site of ONR research in Ocean Thermal Energy Conversion where a heat exchanger test facility has been recently installed at the Natural Energy Laboratory Hawaii Authority (NELHA) facility at Kona.

Manpower, Personnel, Training and Education

ONR's Capable Manpower FNC is developing innovative products to support Human Capital programs, including manpower, personnel, training, and human systems design products. These will optimize performance, minimize personnel costs, and ensure systems are built to accommodate users that will operate, maintain, and support the systems. Capable Manpower will develop a suite of integrated analytical tools to assist managers to forecast and assess effects of enlisted/officer behavior (recruitment, retention, career decisions, education benefits, etc.) resulting from current and proposed Navy policies. These tools will help meet the CNO/SECNAV goal of creating a

workforce that integrates the total force and adopts personnel policies to make Navy competitive in the marketplace. Another goal is to improve availability and reliability of critical information needed by the command team. To achieve this goal, the program will develop information architecture for combat control rooms blending key elements of information processing, team structure, and display techniques. This program will improve operational decision making by transforming information flow from data-centric architecture requiring significant cognitive effort to integrate and validate the tactical picture – to decision-centered architecture that frees the command team to allocate more cognitive energy to the complexity of the mission. This architecture will guide information system design, manning and training for the submarine Ohio Replacement program control room, as well as surface combatant combat information centers. A unique human systems design approach is developing processes, methods and software specifications to merge the full spectrum of human systems integration into Navy's standards-based, open-architecture, Integrated Product Data Environment for production ship design. The prototype is also focused on the submarine Ohio Replacement program and will demonstrate decreased acquisition and ownership costs while increasing effectiveness of the resulting system.

Infantry Immersion Trainer

The Infantry Immersion Trainer (IIT) is a revolutionary training system that prepares Marines and Sailors for deployment to today's battlefield. The facility uses virtual reality, physical structures, gaming avatars, pyrotechnics, and live role players – simulating a Southwest Asian village in the midst of combat – to give troops necessary skills to win and survive in battle. Equipped with laser-tag-like weaponry, Marines, Navy Corpsmen, and Army soldiers, walk through realistic dwellings and alleys – including sounds and smells – encountering civilians and enemy combatants. The IIT confronts warfighters with a range of scenarios requiring split-second decisions. High-tech simulation provides a safe, realistic, training environment for learning how to prevent fatal errors before exposure to real threats, with the goal of "making the first fight no worse than the last simulation." The IIT incorporates ONR technologies, DARPA RealWorld game-based simulation system, and technologies sponsored by the Army Research Development and Engineering Command's Institute for Creative Technologies at the University of Southern California. ONR continues to support technology upgrades to the IIT at Camp Pendleton and the IIT under construction at Camp Lejeune.

Marines in Operational Environments

Marines must be able to destroy enemy formations in major contingencies, and be equally able to employ superior Irregular Warfare (IW) skills. ONR took the technology lead in balancing traditional and IW capabilities by providing quantifiable technical advantages to warfighters in Afghanistan. While IW favors indirect, asymmetric approaches, it may employ the full range of military and other capabilities, in order to erode an adversary's power, influence, and will. The Marine Air-Ground Task Forces (MAGTF) of the future must be leaner in equipment. ONR initiatives help reduce the load of Marines and Sailors through lighter materials and technologies, while providing enhanced protection in combat. We initiated a focused approach designed to lighten the load of individual Marines, as well as the MAGTF. Depending on the situation, the weight of gear for a Marine in Afghanistan can average 90 pounds. ONR continues to pursue the latest technology to provide Marines with scalable protection based on mission and threat. The

use of unmanned aerial vehicles and robotics for logistics delivery are capabilities equally applicable to IW and traditional warfare. ONR led efforts to improve survivability of USMC tactical vehicles. Efforts to develop optimized fiber composite materials, amenable to advanced high volume fabrication techniques, and active protection systems for vehicles against rocket propelled grenades and missiles make Marine forces more agile, lethal, mobile and survivable.

Improvised Explosive Devices (IEDs)

IEDs represent a persistent and lethal challenge. Continuing work with the Joint IED Defeat Organization (JIEDDO), ONR efforts aim at attacking IED networks and devices across the entire kill chain, and training our forces. Working with other agencies, ONR is investing in prediction efforts involving terrorist activity: bio-forensic profiling to trace origin, factory location, support networks, placement, and dynamic analysis of suicide bombing. Scientists at Columbia, Drexel, University of Miami, and others in ONR's Automated Image Understanding (AIU) program developed computational methods and algorithms for recognizing hundreds of object categories – including tracking and analysis of human behavior. Our intent is to develop automated identification of people and behavior to highlight potentially threatening situations.

Near-term initiatives include the Advanced Technology Development efforts to neutralize IEDs through improved countermeasures as well as locating and directly attacking devices. Long-term S&T includes sensing systems for detection/tracking of explosive components in ports, coastal, and ocean environments. Efforts are underway to develop man/machine interfaces with the goal of developing unmanned, autonomous systems to separate warfighters from hazardous missions, providing increased economy of force. ONR's emphasis on autonomy and development of unmanned systems technologies is embedded throughout the S&T portfolio.

Naval Medical Research

ONR's medical research investments include a large variety of basic through applied efforts addressing pre-deployment care and injury prevention, point-of-injury care, en route and automated care, and post-deployment care, treatment, and restoration. The overarching goals are the prevention and treatment of outcomes that negatively impact warfighter health. Major areas of focus are trauma medicine, casualty prevention, stress physiology, undersea medicine and noise induced hearing loss. Trauma medicine efforts include the development of low-volume resuscitation fluids or medical treatments that are easily stored in ambient temperature, affordable, and administered by the individual. Casualty prevention and stress physiology programs include the characterization of blunt trauma effects, models of the physical and cognitive effects of blast exposure, stress and fatigue management, and the prevention of injury associated with operating in military environments. Undersea medicine, a National Naval Responsibility program, focuses on submarine and diver health and performance with specific emphasis on developing novel strategies that address the health threats associated with decompression illness and oxygen toxicity. ONR is the lead DOD agency for the noise induced hearing loss program with efforts aimed at understanding the physics of noise, reducing noise at the source, monitoring noise exposure and designing new protective equipment, and developing pharmaceuticals for hearing loss prevention and treatment.

Affordable Platforms

Technologies to achieve Total Ownership Cost reduction while maintaining or improving system and platform performance are embedded throughout the S&T portfolio. ONR efforts such as the Navy Manufacturing Technology (ManTech) Program and the Enterprise and Platform Enablers FNC contribute to affordability in acquisition programs and throughout the lifecycle of systems and platforms. ManTech continues to focus on technologies to reduce costs of processing and fabrication for composites, electronics and metals, shipbuilding and repair technology, with technical engineering support with demonstrated savings for DDG 1000, CVN 21, Littoral Combat Ship, and VIRGINIA Class Submarines. The VIRGINIA Class Submarine Affordability Initiative, focused on acquisition cost savings since FY 2006, realized cost savings in Block III totaling over $20 million per hull to date. With projected planned investment of approximately $62 million, savings are estimated to grow to over $32 million per hull.

Modular Open System Architecture

Technology is advancing at an ever-increasing rate. Modular open system architecture enables Navy to procure, modernize and integrate complex systems for all classes of ships, enabling affordable upgrades for new technical advances in response to new threats. One example is the multi-function Electronic Warfare-Electronic Sensing (EW-ES) system ONR delivered to Program Executive Office – Integrated Warfare Systems (PEO-IWS). The system met operational requirements with scalable, open system architecture, allowing S&T results to be used not only for DDG 1000, but for scaled back-fit of all ships requiring EW-ES capability. Similarly, the Affordable Common Radar Architecture program developed architecture for future radars in which the system is divided into frequency independent subsystems which need be developed only once. They can be used for all radars regardless of frequency dependent subsystems, enabling Navy to procure the best components from any company and affordably upgrade only necessary elements. This led ONR to bring together system integrators with acquisition components to develop Naval Radio Frequency (RF) modular open system architecture for the Integrated Topside INP. This will enable Navy to use modular construction to procure RF communications, moderate to low power radar, and electronic warfare capability across ships with common RF hardware. In turn, this will reduce developmental acquisition, training and maintenance costs, while enabling affordable upgrades that can keep agile pace with technology and the threat.

Information Dominance and Autonomy

The Naval services need for information dominance – without growth in manpower – must be achieved through fundamental advances in automated understanding and integration of highly diverse sensor and open source data, as well as the ability to automatically provide assessment and warning. ONR advances in automated image and video understanding in the 1990s became the foundation for many image and video industry standards today, as well as algorithms used by the National Geospatial Intelligence Agency, other intelligence organizations, and industry. We also invested in advancing the science of understanding, manipulating, and integrating so-called "soft" data such as human intelligence and open source data.

Even after the integration of large volumes of data, the task of assessing results across a dynamic battlespace is formidable, and currently requires extensive manpower. To automate this requires major advances in machine reasoning and intelligence. ONR sponsored workshops with the Air Force, Army, DARPA, academia, industry, and other DoD participants to focus on critical issues and identify promising opportunities and high priority S&T investments. This research forms the essential foundation enabling large, diverse, mission-focused autonomous sensor/information networks for supporting rapid, accurate decision-making by commanders in the battlespace.

Understanding Ocean Environments

Understanding the marine environment as a coupled system of atmosphere and ocean is critical for Naval operations including: Anti-Submarine Warfare, Mine Counter-Measures, Surface Warfare, and Naval Special Warfare. Although our capabilities steadily increase, there remains much to learn about ocean processes. One of our challenges is to better understand how tides mix ocean water masses to create currents which affect propagation of sound in the ocean. Our goal is to capture the worldwide effect of tides in our prediction systems. ONR conducts research in partnership with the National Science Foundation and agencies in the University National Oceanographic Laboratory System (UNOLS) to allow joint scheduling and operations for the fleet of research ships used by academic oceanographers. In addition, ONR supports S&T investments dedicated to effective and responsible stewardship of the marine environment, including assessing the impact of national security activities on marine mammals.

Small Business Innovation Research (SBIR)

Unique among S&T tools are the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, which apply a combined 2.8% of externally-executed Navy Research, Development, Test and Engineering (RDT&E) funding to high-priority warfighter needs identified by Fleet/Force acquisition programs. Funded at $343 million in FY10 ($384 million when combined with the complementary STTR program), Naval SBIR focuses on ensuring quick, cost-effective delivery of innovative small business technologies to the Fleet/Force.

Naval SBIR supports delivery of innovative technology, providing incentives to ensure timely engagement by prospective customers and investors. Phase I awards of approximately $150 thousand each (with 545 awards in FY 2010) include a base-plus-option strategy to ensure business continuity as Proof of Principle is established. Phase II awards of approximately $1 million each to mature project work (with 296 awards in FY 2010) include a similar funding strategy with technology decision-gates that ensure continuous engagement with acquisition programs to verify "technology pull" from Naval customers. Naval SBIR customer engagement extends to industry through dialogue about technology innovation, including events such as our annual *Navy Opportunity Forum*, where innovators, industry and government customers learn about small business innovation opportunities.

Naval SBIR used the FY 2006 congressionally-mandated Commercialization Pilot Program to accelerate the transition of technologies, products and services developed under SBIR into Naval acquisition pipelines. This led Navy to develop flexible funding mechanisms and application of

Transition Assistance Program tools for SBIR award-winners, helping make SBIR projects more attractive to DoD and industry investors. Naval SBIR makes a valuable contribution to S&T innovation, Naval RDT&E, acquisition programs, small business development and job creation.

ONR Global

There is a worldwide dimension of S&T reflected in over 100 percent growth in global S&T investment over the last ten years. When Congress established NRL in 1916 and ONR in 1946, the U.S. was arguably the world wide leader in S&T development and innovation. However, the U.S. monopoly no longer exists, making it imperative that we keep our finger on the pulse of S&T in the international environment. Beginning with the establishment of our London office in 1946, ONR established offices in Santiago, Prague, Tokyo and Singapore, closely coordinated with the other services and the Assistant Secretary of Defense (Research and Engineering). These offices provide our window on S&T developments in South America, Europe, and Asia.

The purpose of our effort is to search the globe for emerging scientific research and advanced technologies that enable ONR to address both current Fleet/Force needs, as well as requirements of future Naval missions and capabilities. We do this by working through ONR Global offices to establish new contacts and leverage relationships with international leaders in relevant research fields. This allows us to gain new perspectives and expertise, identify geographically significant trends and advances, and help forecast global trends and threats. It also enables us to recruit the world's best and brightest in research partnerships that benefit U.S. forces and allies.

ONR Global programs include the Science Advisor Program which communicates Fleet/Force capability needs to the Naval Research Enterprise (NRE) (consisting primarily of the Navy labs, warfare centers and affiliated universities) and facilitates the development of solutions that can transition back to the Fleet/Force. Program participants are typically engineers who coordinate and conduct Naval experimentation, develop prototype solutions, define transition options, and collaborate with Fleet/Force to define S&T investment needs to meet future Naval requirements.

To increase Naval awareness of global technology, our International Science Program provides scientists from academia, government and industry opportunities to engage leading international scientists and innovators. Our worldwide technical staff helps establish relationships with international leaders in relevant fields, establish direct collaboration between ONR and NRL scientists and their foreign counterparts, and identify significant trends, accomplishments, and centers of excellence for Naval S&T. This strengthens our ability to forecast both trends and threats in global S&T, and avoid technological surprise.

Conclusion

Thank you for the opportunity to discuss Naval S&T. The FY 2012 President's Budget request will enable us to continue moving toward greater integration of capabilities, more effective partnership between research and acquisition, and a clearer vision of how to achieve shared goals among the Army, Air Force, DARPA and other DoD research organizations. At the same time, we continue to focus most of our investment on external performers – outside the Naval R&D system – in order to tap into the full spectrum of innovative thinking and discovery, and to

accelerate transition of appropriate technologies to civilian use. For example, algorithms developed for sonar signal processing have been adapted and are now used for improved Breast Cancer detection.

For all of these reasons, I believe the state of our S&T investments is sound; represents careful stewardship of taxpayer dollars; and will significantly enhance the safety and performance of our warfighters as they serve in defense of the United States, today and in the future. Thank you for your support.

United States Navy
Biography

Rear Admiral Nevin P. Carr, Jr.
Chief of Naval Research
Director, Test and Evaluation and Technology Requirements

Rear Admiral Carr has spent his Navy career at sea in cruisers and destroyers, operating in the Mediterranean Sea, Black Sea, Indian Ocean, Arabian Gulf, North and South Atlantic, South Pacific, Baltic, Caribbean, Arctic and Red Seas. Shipboard tours included USS *King* (DDG 41); USS *McCandless* (FF 1084); USS *Thomas S. Gates* (CG 51); USS *Vella Gulf* (CG 72); Cruiser/Destroyer Group 8 staff embarked in USS *Dwight D. Eisenhower* (CVN 69); and the 2nd Fleet staff embarked in USS *Mt. Whitney* (LCC 20). He commanded USS *Arleigh Burke* (DDG 51) and USS *Cape St. George* (CG 71), winning Battle Efficiency Awards and Golden Anchors in both tours. While in command of *Cape St. George*, the ship participated in combat operations in support of Operation *Iraqi Freedom* in both the European and Central Command theaters.

Ashore, Carr has served in the Office of the Secretary of Defense where he worked on the Arleigh Burke, Ticonderoga and Seawolf programs, and several Ballistic Missile Defense programs. He later served in the Office of the Chief of Naval Operations as requirements officer for the Aegis Cruiser and Destroyer programs, and was executive assistant to the commander, U.S. Fleet Forces Command. Following promotion to flag rank in 2006 he was assigned as the deputy director of Surface Warfare for Combat Systems and Weapons, and later as deputy assistant secretary of the Navy (International Programs) and director, Navy International Program Office.

Carr graduated in 1979 from the U.S. Naval Academy with a Bachelor of Science in Naval Architecture. He earned a Master of Science in Operations Research from the Naval Postgraduate School and completed the Advanced Management Program at Harvard Business School.

In December 2008, he became the 22nd chief of Naval Research, with additional duties as director, Test and Evaluation and Technology Requirements.

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BY THE ARMED SERVICES COMMITTEE
SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITES
UNITED STATES HOUSE OF REPRESENTATIVES

DEPARTMENT OF THE AIR FORCE

PRESENTATION TO THE HOUSE ARMED SERVICES COMMITTEE

SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

UNITED STATES HOUSE OF REPRESENTATIVES

SUBJECT: Fiscal Year 2012 Air Force Science and Technology

STATEMENT OF: Dr. Steven H. Walker, SES
Deputy Assistant Secretary
(Science, Technology and Engineering)

March 1, 2011

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INTRODUCTION

Mr. Chairman, Members of the Subcommittee, and Staff, I am pleased to have the opportunity to provide testimony on the Fiscal Year 2012 Air Force Science and Technology (S&T) Program.

The United States continues to face a vast array of diverse and complex security challenges. From the current conflicts in Iraq and Afghanistan to unknown threats of the future, the United States Air Force must balance its investments to be prepared to defeat adversaries and succeed in a wide range of contingencies. Since testifying before this Subcommittee last year, the Air Force has developed and published an S&T Strategy, the first of its kind since 2004, and created a collaborative S&T Planning Process. The S&T Strategy, signed by our Secretary and Chief of Staff, provides a framework for the S&T community to develop a balanced portfolio that ensures we are technologically prepared for an uncertain future while developing the necessary technology for our warfighters operating around the world today. This balance is often referred to as technology push from the laboratory versus technology pull from the warfighter. We sought to strengthen the technology pull piece of our portfolio by creating an S&T planning process that is built on engagements between the Air Force Research Laboratory (AFRL), Product Centers, and warfighters. These engagements are centered on the twelve Air Force Service Core Functions and result in technology solutions to warfighter capability needs that are vetted and approved by an Air Force Headquarters-led S&T governance process.

AIR FORCE S&T FISCAL YEAR 2012 PRESIDENT'S BUDGET REQUEST

The Air Force Fiscal Year 2012 President's Budget request for S&T is approximately $2.3 billion, which includes approximately $200 million in support of devolved programs consisting of High Energy Laser efforts and the University Research Initiative. These investments support a robust and balanced foundation of basic research, applied research, and advanced technology

development to provide demonstrated transition options to support future warfighting capabilities. This year's budget request includes an increase of $95 million or 2.8 percent real growth from the Fiscal Year 2011 President's Budget request. This increase reflects Air Force leadership's steadfast support for its S&T Program, even in the face of a very challenging fiscal environment.

Within the S&T portfolio, significant adjustments were made to address our warfighters' most pressing needs for technological solutions. These included advanced technology development increases of $38 million in our munitions portfolio, $14 million in the air vehicles portfolio, and $11 million in the directed energy budget. At the same time, we increased the budget for basic research by $18 million to maintain a balance between the known challenges of today and the uncertainty of the future.

AIR FORCE S&T SUPPORTS AIR FORCE STRATEGIC PRIORITIES

The Air Force S&T Program creates compelling air, space, and cyberspace capabilities for precise and reliable Global Vigilance, Reach, and Power for our Nation. It provides the foundation for the majority of the Air Force's following five Strategic Priorities:

- Continue to Strengthen the Nuclear Enterprise
- Partner with the Joint and Coalition Team to Win Today's Fight
- Develop and Care for Airmen and Their Families
- Modernize Our Air, Space, and Cyber Inventories, Organizations, and Training
- Recapture Acquisition Excellence

These strategic priorities, along with input from the Capabilities Review and Risk Assessment, warfighter capability needs, S&T Vision as articulated in *Technology Horizons*, and our S&T Strategy, inform our new S&T planning process to help shape our S&T investments. The S&T planning process was created over the past year with extensive participation from across all levels of the Air Force. This process provides a framework for the Major Commands, Product Centers, and

AFRL to work collaboratively to identify and understand both technology needs and potential solutions. A collaborative Needs and Solutions Process is essential to ensure the laboratory is aware of warfighter capability needs and acquisition technology needs, and that the laboratory's technology solutions meet both these needs. Embedded within the S&T planning process is the Air Force S&T Governance Structure, co-chaired by the AFRL Commander and me as the Deputy Assistant Secretary (Science, Technology and Engineering), with responsibility for prioritizing and commissioning proposed S&T demonstrations for which the Air Force makes a corporate commitment to transition. In addition to commissioning specific S&T demonstrations, the Governance Structure improves the cross-flow of information between warfighters and provides Air Force-level awareness of the S&T portfolio. The results of the S&T Governance Structure culminate with a review and endorsement by the Air Force Requirements Oversight Council (AFROC). Findings of the AFROC are then signed out by the Vice Chief of Staff.

AIR FORCE S&T TENETS

The Air Force S&T Program is directed by senior Air Force leadership and is based on the following enduring tenets, documented in the Air Force S&T Strategy. First, we must prepare for an uncertain future and investigate game-changing technologies to affordably transition the art-of-the-possible into military capabilities. We will create technology options that address urgent warfighter needs and provide new capabilities in support of the Air Force Service Core Functions. In this time of constrained fiscal realities, advanced technologies must be demonstrated 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 will foster an appreciation for the value of technology as a force-multiplier throughout the Air Force. We will maintain in-house expertise to support the acquisition and operational communities and modernize and improve the sustainability of unique research facilities and

infrastructure. Finally, we will remain vigilant over and leverage 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 PROGRAM PRIORITIES

The Air Force S&T Fiscal Year 2012 President's Budget request supports the following overarching priorities that are detailed in the Air Force S&T Strategy. While the S&T Priorities reflect the S&T Tenets, they are not intended to be as enduring because we must have the flexibility to adjust priorities in response to various environmental influences.

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

We must invest in S&T that will enable the Air Force to operate effectively and achieve desired results in all domains and operations, both today and in the future. The Air Force Rapid Reaction and Innovation Process addresses near-term warfighter needs through the rapid infusion, integration, and innovation of S&T-based solutions that capitalize on the breadth and depth of the S&T Program. This process is designed to tightly integrate S&T knowledge with operator knowledge to deliver solutions to the warfighter in 12 months or less.

In the past year, we've developed several quick reaction solutions to provide near-term support to our warfighters. In response to an Air Force Special Operations Command request to rapidly determine ground bearing strength for landing aircraft in remote sites, we developed a man-portable motorized dynamic cone penetrometer. Air Mobility Command requested weather sensing technology to enable single pass airdrop for C-17 and C-130 aircraft. In response to this request, we developed a pod for a tactical remotely piloted aircraft to pre-deploy a wind measuring dropsonde.

Recently, munitions scientists from AFRL teamed with the Lawrence Livermore National Laboratory to design and test an advanced composite-case warhead to provide a precision lethality

munition with low collateral damage capability. The composite warhead case disintegrates during the explosion and minimizes fragmentation, thus decreasing damage and injury to nearby structures and personnel, including friendly forces and innocent civilians. This effort is a showcase for close cooperation between the munitions research, development, and production communities to rapidly provide a valuable new munition capability for the warfighter.

Basic research in numerous emerging scientific areas may enable dramatic technological advances over current capabilities that will be essential for the future Air Force. We are conducting research in Information Assurance to develop a unified science of security that incorporates the human user, software, hardware, and methods for achieving substantially improved intrusion resistance and intrusion-tolerance in Air Force cyber systems. Research in Network Sciences is analyzing different classes of interacting networks, identifying methods of separation of superimposed networks, identifying the mechanisms of how these networks interact, and characterizing their integrated properties. There is significant research being done to enable Transformational Computing. We are developing autonomous electronic neuromorphic devices and systems, along with enabling science, that scale to biological levels of performance. This research aims to achieve high computational performance, adaptation, flexibility, self-repair, and other forms of intelligent behavior in complex, uncertain, and highly dynamic environments.

In the area of Socio-Cultural Modeling we are developing computational and modeling approaches to study factors and causes of the emergence of terrorist organizations, the recruitment and retention of members of terrorist organizations, terrorist ideologies, and formulate hypotheses about adversaries' intentions.

Research in the area of Physics and Chemistry of Surfaces in Highly Stressed Environments includes the design of techniques and experimental measurement of surface phenomena from the atomic scale up through the macro scale. Additional topics include nanofabrication of complex

surfaces, study of physical and chemical processes by which such surfaces might be modified, and an emphasis on the interaction of electromagnetic radiation with complex surfaces.

Exploiting the revolutionary advances in nonequilibrium chemistry, nanotechnology, high power laser in situ diagnostics, and multi-scale computational tools will transform the field of traditional optical materials and lead to the creation of "extreme" optics – optics for extreme environments.

We are also investing in technologies to improve the agility, mobility, affordability, and survivability of Air Force assets. To support mobility, we are developing technologies and planning tools for synchronized distributed operations in order to increase the quality of air refueling asset solutions, involving both tanker aircraft and aircrews, to satisfy operational air refueling requirements. These efforts are instrumental to enabling the Global Reach that our Joint and coalition partners have come to rely on from the Air Force. To help improve the affordability of Air Force assets, we are developing technologies that will increase efficiency and effectiveness in learning and training through the use of Distributed Mission and Live, Virtual, Constructive training. To support affordability and agility, we are developing supervisory control interface technologies that will enable a single operator to simultaneously and safely control multiple remotely piloted aircraft.

Focused efforts on producibility, aerodynamic and propulsive efficiency, and weight reduction will translate to improved affordability of future systems. Investments in advanced materials, such as radio frequency and electronic materials, optical and infrared materials, high temperature metals and ceramics, and hybrid materials will help reduce life cycle costs, improve performance, affordability, supportability, reliability, and survivability of current and future Air Force systems and operations.

In addition, efforts are underway in our Robust Scramjet program to develop scramjets that process ten times the airflow of our current scramjet technology demonstrator. These engines will support long-range strike and operationally responsive space access, and will enable the Air Force to achieve desired effects in all domains and operations. The high speeds achievable by scramjet engines will greatly increase the survivability of long-range strike weapons or air platforms penetrating anti-access/area denial environments. Further, when combined with conventional rocket- or turbine-based propulsion systems to form combined cycle engines, scramjets will be able to achieve aircraft-like operation for spacelift vehicles enabling more operationally responsive space access than current expendable launch systems. This will allow for the possibility of operating from runways and will significantly increase launch flexibility to achieve desired orbits.

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

While it is important to develop and execute an S&T portfolio that balances today's warfighter needs with the uncertainty of tomorrow's security environment, it is equally important to identify those emphasis areas where we would invest our next S&T dollar. Priority 2 from our S&T Strategy provides those emphasis areas.

The reality of today's Air Force is that we're fighting today's wars with many of our grandfathers' aircraft and we will continue to live within this reality for the foreseeable future. Therefore, we must improve the sustainment, affordability, and availability of the legacy weapon systems on which we depend. Within the S&T Program, we have a Program Element for sustainment that is dedicated to developing and demonstrating technologies to address operational sustainment issues in existing systems, as well as supporting new systems. While this effort focuses on a small number of topics, it has already yielded results as demonstrated in the area of vehicle health monitoring, where S&T efforts aided in identification of potential system failures.

Under the Technology for the Sustainment of Strategic Systems effort, we are developing advanced aging and surveillance tools that will enable the user to identify individual rocket motor stages that are not expected to meet their projected life goals. Current tools would result in the replacement of an entire production lot of motors. The new tools will help save billions in motor replacement costs.

Sustainment is the primary cost driver for turbine engine investments within the Department. As these costs continue to rise, it has a direct impact on fleet modernization. Our approach to address this is to focus technologies toward the goal of increasing fighter engine average time on wing by two times and reducing propulsion-related Class A Mishaps by 75 percent. The turbine engine community is proactively working with the Air Force on technologies for improved robustness and increased reliability to support fielded engine issues, as well as potential unforeseen issues with future engines.

Development in advanced materials and processes has significantly reduced low observable aircraft repair times, resulting in reduced aircraft downtime. These advanced materials provide a 30 percent reduction in cure times and can be applied over a larger window of environmental conditions. In addition to supporting legacy aircraft, this technology directly supports the F-22 and F-35 platforms.

While we continue to address issues associated with maintaining our legacy systems, we must also invest considerable resources toward emerging warfighting concepts. Cyberspace superiority enables the precise application of forces in all domains, generates effects across the full spectrum of operations, and preserves an agile and resilient cyberspace infrastructure for assured mission execution. Air Force networks face a continuous barrage of assaults from state-sponsored actors, terror networks, international criminal organizations, individual hackers, and all level of threats in between. Therefore, we must reduce cyber vulnerabilities while emphasizing mission

assurance. We have multiple research efforts addressing this challenge, including cyber situational awareness, host-based defenses, botnet detection and mitigation, and self-healing networks to allow us to fight through cyber attacks. Additionally, our efforts in digital forensics will identify the adversary and source of the attack, enabling active responses as appropriate.

The Air Force has the key responsibility of maintaining the airborne and land-based elements of the nuclear triad. Accordingly, we must support the needs of the nuclear enterprise in the Air Force S&T Program. We have two major S&T objectives in support of the nuclear enterprise – to develop and transition the key S&T required to support current nuclear-capable air and missile systems, command and control, as well as other ground and support systems, and to develop the key S&T to increase the trade space and lower acquisition risks for future development of nuclear-capable systems to replace the present capabilities. S&T investments must address critical aging systems, infrastructure, and future systems holistically. Current technology investments are planned for Advanced Ballistic Missile Guidance Technology, Advanced Rocket Propulsion Technology, Advanced Thermal Protection Materials, and Missile Site Security.

We must invest in technologies to maximize the effective use of both human and machine in warfighting systems through advanced autonomy, human-machine interaction, human performance augmentation, and verification and validation technologies. We have three overall goals for research in these areas. First, we will develop effective, flexible, fault-tolerant, trusted autonomous systems and associated human-machine interaction technologies to increase mission effectiveness of unmanned assets while reducing manning requirements and training times. Second, we must develop advanced software verification and validation technologies to ensure autonomous system technologies can be certified for operation in a timely and efficient manner and to facilitate rapid building of trust in those systems. Finally, we seek to develop human performance augmentation technologies to increase vigilance, optimize situational awareness, enhance individual and group

performance, reduce learning curves, increase mission effectiveness, and provide lethal combat scenario training and combat simulations in safe environments, while saving money, time, and lives.

As the demand for Intelligence, Surveillance, and Reconnaissance (ISR) continues to grow, the Air Force is aggressively evolving our ISR capability to support combat operations and meet mid-term and evolving threats through enhancements of fielded systems and investing in the future. In order to maintain Global Vigilance, we need to develop technologies that will provide robust situational awareness to enhance decision-makers' understanding and knowledge by improving ISR capabilities and data processing, exploitation, and dissemination. To accomplish this, we are conducting research and development programs to provide persistent ISR, including integrated wide area surveillance sensors in the electro-optic, infrared, and radiofrequency domains. We are developing higher-level fusion and the enabling text information and knowledge base technologies to achieve situational awareness and understanding at all command levels for dynamic planning, assessment, and execution processes. We are developing digital information exploitation technologies for electronic communications and special signals intelligence, imagery, and measurement signatures to increase accuracy, correlation, and timeliness of the information. This information will feed the next generation of monitoring, planning, and assessment technologies that will predict the most probable adversarial courses of action and corresponding blue courses of action, enabling aerospace commanders to develop effects-based campaigns.

For the Air Force to continue to provide the critical capability of Global Power, we must sustain our ability to hold virtually any target on the planet at risk. This will require the development of a long-range precision strike capability to create desired effects across the full range of military operations and ensure appropriate redundancies. Our S&T investments are enabling the development of this capability. The X-51A Scramjet Engine Demonstration had a successful first flight on May 26, 2010, demonstrating release, boost, separation, scramjet ignition, and initial

acceleration. Two additional flights in Fiscal Year 2011 and one in Fiscal Year 2012 will expand the flight envelope to Mach 6. In Fiscal Year 2012, we will begin weaponizing the X-51 research vehicle. Development activities will focus on miniaturization of subsystems to allow for a payload and the ability to cold start the weapon after release from an aircraft.

The Air Force views energy efficiency as a mission enabler that can increase combat effectiveness, expand reach, and minimize operational risks. We are integrating energy considerations across the Air Force enterprise by reducing demand, increasing supply, and creating a culture that makes energy a consideration in everything we do. Air Force S&T invests significant resources in a diverse energy technology portfolio. With efforts in improved turbine engine fuel efficiency, alternative fuels, aerodynamic improvements, lightweight materials, and a host of other efforts, Air Force S&T is developing numerous technologies from which future energy-efficient weapon systems will be built.

We are continuing to push the envelope in propulsion technology to increase engine performance while improving fuel efficiency. The Integrated Vehicle Energy Technology (INVENT) program is developing energy-optimized aircraft subsystems and tip-to-tail energy optimization simulation capabilities that will enable enhanced capabilities for future Air Force platforms, including next-generation tactical and ISR platforms.

The Air Force invests heavily in developing new technologies for aircraft turbine engines. In particular, there are three ongoing research efforts developing the next generation of advanced turbine engines. The Adaptive Versatile Engine Technology (ADVENT) program is developing multi-design-point engine technologies that will provide optimized fuel efficiency of up to 25 percent and performance capabilities over a wide range of flight regimes. The follow-on Highly Efficient Embedded Turbine Engine (HEETE) program is developing low-observable-compatible, subsonic propulsion technologies that will provide up to a 35 percent improvement in specific fuel

consumption. The Efficient Small Scale Propulsion (ESSP) program develops advanced small scale propulsion technologies that will provide up to a 30 percent improvement in specific consumption, production cost, and development cost.

Progress in the development of alternative fuel sources for Air Force and other Department of Defense (DoD) platforms will be significantly aided by the recently commissioned Assured Aerospace Fuels Research Facility at Wright-Patterson Air Force Base, Ohio. The ability to develop research quantities of alternative fuels will help enable the development of domestically-produced, environmentally-friendly, cost-effective fuels for future air platforms. Additionally, the Advanced Power Technology Office (APTO) became part of AFRL in October 2010 and is developing advanced alternative energy and fuel technologies to reduce the dependency on foreign energy sources.

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

In order to deliver capabilities from across the breadth of investments I've just discussed, we must have a dedicated, educated, and highly-skilled workforce of Scientists and Engineers (S&E). One avenue we can use to hone these needed skills is to increase the level of in-house basic research to allow our researchers to do hands-on laboratory work. This work will go through a rigorous merit peer review process similar to that for university proposals. We are actively seeking to improve our intramural basic research program. Recent efforts include emphasizing increased participation of early career researchers performing in-house basic research to ensure the development of a skilled S&E workforce. We are growing our National Research Council Resident Research Associates (Post-Doctoral) program and Summer Faculty Fellowship program which bring academic and industry expertise to Air Force research sites.

While all of our S&Es need the opportunity to enhance their critical competencies, we are particularly mindful of the needs of our relatively new organic cyber workforce. Our Fiscal Year 2012 budget request continues to emphasize research, as well as technology development and demonstration, in the cyber domain to allow us to grow our cadre of cyber S&E experts to protect and defend information networks. The Air Force Institute of Technology recently began offering a Cyber Security Boot Camp Course that was originally developed by AFRL at Rome, New York. The course is a summer program for Reserve Officer Training Corps (ROTC) cadets studying computer science, computer engineering, and electrical engineering. The program consists of an instructional component and cyber war games, hands-on internships, and cyber officer development days that focus on the study of cyber as a revolution in military affairs.

Even as we support and develop the S&Es working in our laboratory today, we must also support Air Force Science, Technology, Engineering, and Mathematics (STEM) initiatives to develop and optimally manage the S&E workforce of the future. *Bright Horizons*, an Air Force STEM strategic roadmap for shaping the way the Air Force manages its mission-critical STEM capabilities, is currently in coordination and is expected to be signed this spring. We are establishing an Air Force STEM Office to create policy and processes and to coordinate outreach activities. STEM initiatives will be aligned with the following major goals:

- Develop accurate and timely STEM-related manpower requirements across the Air Force
- Establish adequate and predictable funding levels in terms of funded military billets, civilian pay, and career field management
- Aggressively use force management practices to build and maintain a highly competent, diversified, and agile force at the right grade levels, at the right time, and appropriate locations

- Support and build lasting relationships with the best university undergraduate and graduate students working in fields important to the Air Force – educate students on Air Force S&T needs and Air Force career opportunities
- Aggressively pursue strategic partnerships and outreach activities with our schools, universities, sister Services, professional associations, and other Federal agencies – the Air Force has outreach initiatives that connect with over 30,000 students and 1,000 teachers
- Develop and apply measurements that drive business behaviors across the Air Force to be consistent with the vision and goals of the pending *Bright Horizons*.

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

It is critical to Air Force modernization efforts that the S&T Program be a trusted partner of the acquisition and sustainment community to assess technology maturity and accelerate technology transition. We are working with Air Force warfighters to develop the technologies to address their most pressing needs and we must do everything possible to facilitate transition of this technology. As part of the S&T Planning Process, we created Flagship Capability Concepts – these are Air Force-level integrated Advanced Technology Demonstrations with well-defined scope and specific objectives that are desired by a Major Command and will be matured by AFRL with the intent for transition to the acquisition community to be deployed to an end user. These Flagships are sponsored by the using command and are vetted through the S&T Governance Structure to ensure they align with Air Force strategic priorities. The results of the S&T Governance Structure are briefed to the AFROC and are ultimately endorsed by the Vice Chief of Staff, indicating that these are the highest priority S&T efforts for transition. After approval, Flagships are managed like acquisition programs with regular reviews of cost, schedule, and performance. Additionally, the

Flagships are linked with the Air Force Development Planning process to ensure adequate systems engineering and pre-acquisition planning is accomplished for transition to an acquisition program.

The Vice Chief of Staff recently endorsed the first three Air Force Flagship Capability Concepts. The High Velocity Penetrating Weapon was established to demonstrate critical technologies to reduce the technical risk for a new generation of penetrating weapons to defeat difficult hard targets. These weapons will use a higher velocity impact to increase warhead penetration capability required for emerging high-strength targets in difficult environments. Advanced technologies will enhance weapon kinematics, ensure precision guidance in contested environments, and dramatically reduce the size of the overall weapon. The ultimate goal is to demonstrate 5,000-pound-class weapon penetration capability in a 2,000-pound-class weapon. As a result, future fighter aircraft will be able to deliver bunker-busting capabilities currently associated only with the bomber fleet.

The second Flagship addresses the high cost of space access. The Responsive Reusable Boost for Space Access concept will develop and demonstrate technologies to reduce the cost of space access by 50 percent and also provide Air Force Space Command with the capability for responsive, almost aircraft-like access to space. The technologies include autonomous guidance, navigation, and control enabling unmanned operation; advanced structures and subsystems; and a reusable hydrocarbon-fueled engine technology demonstrator. If successful, this technology concept would compete as a replacement for the current fleet of expendable rockets.

The last Flagship Capability Concept, Selective Cyber Operations Technology Integration, provides cyber technologies capable of affecting multiple nodes for the purposes of achieving a military objective. This will provide a non-kinetic means to deny, degrade, deceive, disrupt, or destroy an adversary's operations.

In order to be successful with our Flagship Capability Concepts or any other efforts in our S&T Program, we must leverage research and development within industry, including small businesses. The Air Force Independent Research and Development (IR&D) program executes a three-step process to transmit Air Force technology needs to industry, gather information on relevant industry IR&D efforts, and align industry and Air Force investment plans to address technology gaps and eliminate redundancies. AFRL and Air Force Product Centers also host a wide variety of forums, such as Industry Days and Dialogue with Industry, to inform industry of plans regarding current and future acquisition programs. The Air Force Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) program executes an annual budget of over $350 million to develop innovative new technologies from small businesses. SBIR also administers a Commercialization Pilot Program that partners promising SBIR companies with prime contractors to assist the transition of SBIR-developed technologies into industry projects supporting Air Force needs. The Air Force Technology Transfer program offers industry partners tailored opportunities for access to advanced technology, the unique chance to work directly with top Air Force S&Es, and the invitation to take advantage of specialized facilities and equipment.

Another area critical to the successful transition of technologies is to develop and demonstrate technology solutions that decrease manufacturing risks. The Air Force Manufacturing Technology (ManTech) program continues to reduce acquisition and sustainment costs, time, and risk while increasing the availability of advanced technologies for the warfighter. In 2010, the ManTech program completed transition of a "Manufacturing Readiness Level" assessment tool that enables acquisition programs to quantitatively assess the manufacturability of new technologies. This tool will reduce the programmatic risk in acquisition, as well as accelerate the transition of breakthrough technology. Capitalizing upon digital information is a key tenet in ManTech's future and will decrease future manufacturing risks. Computational techniques to model and predict the

behavior of manufacturing processes and supply chains will enable tomorrow's systems designers to simulate production strategies for far less time and money than conventional "build and bust" approaches. This Advanced Manufacturing Enterprise ability to "war-game" a manufacturing scenario based upon supply chain disruptions will allow the Air Force to forecast part shortages based upon pending socioeconomic factors and avoid production delays. Direct Digital Manufacturing (DDM) techniques utilize digital computer-aided design data and produce net shape metallic and polymer components using the latest laser and profilometry technologies. Last year, ManTech demonstrated DDM to manufacture a small remotely piloted aircraft. The time from computer-aided design data development to part production and assembly was less than one week as compared to conventional design and manufacturing approaches that took over three months for similar components. The Air Force ManTech program also continues to lead the nation in developing advanced manufacturing technologies for high temperature ceramic composite and super alloy turbine engine components, aircraft structural materials, radars for Actively Scanned Electronic Arrays, precision-guided weapons, satellite communication links, and solar cells. We also develop and transition new technologies to the depot systems as part of the High Velocity Maintenance program.

CONCLUSION

The Air Force S&T Program is balanced to address warfighting needs – both near-term and far-term. Science and knowledge provide the foundation of the S&T Program, laying the cornerstone of the future force. It is here that leading-edge scientific discoveries are transformed into new technologies turning the art-of-the-possible into the state-of-the-art. Through regular interaction with the warfighter, we are better able to understand their capability needs and address these needs by leading and harnessing innovation across Service laboratories, government agencies,

industry, and academia. These efforts mitigate risk and form the basis for new capability concepts – the highest priority of which are designated as Flagship Capability Concepts.

The Air Force investment in S&T ensures the infusion of revolutionary and evolutionary S&T-enabled capabilities that are needed to maintain air, space, and cyberspace dominance across all twelve Air Force Service Core Functions. By embodying the S&T Tenets documented in the recently released Air Force S&T Strategy, focusing on the S&T Priorities, and utilizing the process of turning science into capabilities, the Air Force S&T Program will provide the technological edge needed to win today's fight and prepare for tomorrow's challenges.

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

BIOGRAPHY

UNITED STATES AIR FORCE

DR. STEVEN H. WALKER

Dr. Steven H. Walker, a member of the Senior Executive Service, is Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering, Office of the Assistant Secretary of the Air Force for Acquisition, Washington, D.C. Dr. Walker is responsible for preparing policy, guidance, and advocacy for the Air Force's annual $2 billion science and technology program. He provides annual testimony to Congress, technical advice and counsel to the Air Force Acquisition Executive, and the Air Force's science and technology recommendations to the Office of the Secretary of Defense. In addition, Dr. Walker is responsible for overseeing a broad range of engineering and technical management policy spanning systems engineering; environmental safety and occupational health; industrial preparedness; and functional management of more than 14,000 military and civilian scientists and engineers.

Dr. Walker has more than 20 years experience in civil service. He began his engineering career in the Air Force Research Laboratory's Air Vehicles Directorate in Dayton, Ohio, providing expertise in airplane exhaust system fluidics and aero-acoustic modeling and simulation research. Subsequent assignments include Program Manager of the Unsteady Aerodynamics and Hypersonics Research Program at the AFRL's Air Force Office of Scientific Research in Arlington, Va., and special assistant to the Director, Defense Research and Engineering at the Pentagon. Dr. Walker has also served in the Tactical Technology Office at the Defense Advanced Research Projects Agency. As a Program Manager in the TTO, he initiated the $500 million DARPA/Air Force Falcon program to develop and flight test technologies for long duration hypersonic flight and affordable, responsive space lift. Prior to his current assignment, he was the TTO Deputy Director.

Dr. Walker is an Associate Fellow of the American Institute of Aeronautics and Astronautics where he has served on the AIAA Air-Breathing Propulsion, Aero-acoustics and Fluid Dynamics Technical Committees. He has written numerous technical publications based on his research and experience.

EDUCATION

1987 Bachelor of Science degree in aerospace engineering, University of Notre Dame
1991 Master of Science degree in mechanical engineering, University of Dayton
1997 Doctor of Philosophy degree in aerospace engineering, University of Notre Dame

CAREER CHRONOLOGY

1.1987 - 1997, research and development engineer, Air Vehicles Directorate, Air Force Research Laboratory, Dayton, Ohio
2. 1997 - 2001, Program Manager, Air Force Office of Scientific Research, Arlington, Va.
3. 2001 - 2002, special assistant to the Director, Defense Research and Engineering, the Pentagon,

Washington, D.C.
4. 2002 - 2006, Program Manager, Tactical Technology Office, Defense Advanced Research Projects Agency, Arlington, Va.
5. 2006 - 2010, Deputy Director, Tactical Technology Office, Defense Advanced Research Projects Agency, Arlington, Va.
6. 2010 - present, Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering, Office of the Assistant Secretary of the Air Force for Acquisition, the Pentagon, Washington, D.C.

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Statement by

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It is said that "Vision without execution is daydreaming."[1]

There is a time and a place for daydreaming. But it is not at DARPA. DARPA is not the place of dreamlike musings or fantasies, not a place for self-indulging in wishes and hopes. DARPA is a place of doing. A place where vision is paired with execution. Where new things are imagined and then turned to reality. Where doing is as powerful a force as thinking. And where it is commonplace for something once deemed impossible to become improbable and then inevitable. It is a place where the Nation's best scientists and engineers go to serve a purpose greater than self. Together, they form the Nation's army of technogeeks with vision, and they "make it so." They stand on a 50-year history of people who changed the world.

DARPA's singular mission is to the technological superiority of the Nation's Defense; specifically, the creation and prevention of strategic surprise. Chairman Thornberry, Ranking Member Langevin, Members of the Subcommittee, my name is Regina Dugan. I am the Director of the Defense Advanced Research Projects Agency. I'd like to center our discussion today on the accomplishments of the Agency over the last 12 months and, as well, in support of our budget request, our intentions for the coming year.

Some mistakenly believe that strategic surprise necessarily conforms to a predetermined timeline. Strategic surprise can occur on any timescale. We get a vote. And so does the adversary. Sometimes it requires 5 to 10 years... sometimes only 90 days. This full dynamic range is illustrated in the breadth and scope of work that DARPA does, and it is punctuated by the intensity of our support to ongoing operations. The authenticity of such engagements inspires greater genius. And it cannot be created in the abstract.

[1] This quotation is attributed to Bill Gates.

DARPA's support to ongoing operations.

In April 2010, shortly after last year's testimony, DARPA stood up Task Force JDOT[2]. It was motivated by a trip to Afghanistan, which revealed that many operators regarded DARPA as the organization to call when they believed they had a 5- to 10-year problem to solve. It seemed clear that many operators did not believe DARPA was in the fight with them. We were determined to change both the perception and the reality of that belief, because when the country is at war, and we can contribute, it is our duty to do so. Indeed, the Agency's participation in ongoing conflicts dates back to the Vietnam War.

At any point in time, DARPA has technologies in all stages of development, from nascent idea to system ready for fielding. Further, the Agency has a unique perspective on emerging technologies, megatrends, talent, and potential opportunities to synthesize advances in disciplines that might be brought to bear quickly to serve the warfighter. The Agency can respond rapidly to provide such support because of its leanness and adaptability.

Under Task Force JDOT, the Agency undertook eight specific efforts in direct support of Afghanistan covering the full spectrum of possibilities. Included were rapid fielding efforts for mature technologies; a 90-day Skunkworks activity that brought together some of the country's best computer and social scientists, counterinsurgency (COIN) experts, economists and analysts; advanced training tools; and organically-developed capabilities that harness crowd sourcing and social networking technologies. DARPA deployed teams to Afghanistan to support operations, sometimes within a month of being asked. These teams deployed not for a week, but for rotations of 3 to 6 months. The Agency stood up a forward operating cell, brought state-of-the-art advances in large-scale computational and visualization techniques to sparse database analysis, and created an in-theater data processing, exploitation, and dissemination cell complete with a full flight team. DARPA personnel work side by side with personnel from large

[2] Joint DARPA Operational Trials

and small companies in 24/7 efforts to meet timelines needed to support forward operations. Some of the Nation's most talented young researchers took leave from their universities to deploy. These engineers and scientists enlisted in the DARPA army of technogeeks. I have watched young men and women, some as young as 27, go toe to toe with four-star generals. Because it mattered, and because it had become deeply personal to them. They decided they could make a difference, so they got in the fight. It is their way of serving country.

Other activities included the fielding of a wide-area high-definition, off-nadir light detection and ranging (LIDAR) collection system to provide much-needed 3D map data. LIDAR systems use light to image objects in the same way that RADAR systems use radio waves. Sensitivity at the photon-counting level matters to operations. The DARPA High Altitude LIDAR Operational Experiment (HALOE) system was five years in the making. It incorporates advances in short-wave infrared sensitive material properties that permitted photon-counting detector arrays so sensitive that it is now possible to make range measurements with fewer than 10 photons received, versus 10's of thousands of photons. As is true with your camera, increased sensitivity means that an image can be captured more quickly—the shutter has to be open for less time. And less light is required to capture an image. Less time and lower power translate to higher collection rates at larger standoff. HALOE can collect data at a rate that is more than 10 times faster than state-of-the-art systems or 100 times faster than conventional systems. At full operational capacity, this means that the HALOE system can map 50 percent of Afghanistan in 90 days. State-of-the-art deployed systems would have required 3 years to accomplish the same task, and more conventional systems would have required 30 years.

Communication nodes to allow coalition voice and data interoperability have also been deployed. Novel training aides based on current technological trends in smart phone application development, immersive simulation environments, and competitive improvised explosive device (IED) detection training are also part of the suite of capabilities.

We fielded systems to increase the risk and decrease the effectiveness of adversary attacks on U.S. helicopters and ground vehicles. Advanced acoustic detection and data processing exploit the supersonic shock wave produced by a bullet in flight to detect the presence and direction of incoming hostile small arms fire against helicopters, which accounts for 85 percent of hostile fire engagements. Last year, a prototype system for helicopter alert and threat termination (HALTT) was installed on an Army UH-60 L Blackhawk helicopter. This year, four HALTT systems were deployed to Afghanistan, with additional deployments scheduled for 2012.

Acoustic arrays and a radar system combine to detect, classify, and track small arms, rocket-propelled grenades (RPGs), and other advanced threats to ground vehicles. CROSSHAIRS geolocates and displays shooter position on an interactive map and then slews to cue an overhead weapon. Both CROSSHAIRS and HALTT began with the vision to detect and counter adversary action at the source. The fielding of both systems in Afghanistan last year was that vision realized.

But we didn't stop there. Net armor surrounding a vehicle is used to crush the casing of an incoming RPG, thereby disrupting the formation of the shape charge and degrading lethal effectiveness. Technically elegant in execution and simply engineered, the ultra-lightweight, low-cost and easily adaptable system met with some initial skepticism.

Until the reports started rolling in... While conducting a patrol along a highly traveled road in eastern Ghazni, insurgents ambushed the Soldiers of 2nd Platoon, B Company, 187th Infantry, 101st Airborne Division. U.S. Army First Lieutenant R.J. Peek reported that on September 19, 2010, from less than 100 meters away, insurgents fired a volley of RPG rounds, followed by a series of machine gun fire and another RPG. In the course of the engagement, U.S. trucks took three direct hits by insurgent RPGs. None had penetrated. The nets performed exactly as advertised, and all of the Soldiers of B Company are alive today.

The breadth, urgency, and technical demand of these activities focus DARPA's work. They offer lasting lessons regarding the challenges of shipping product to customer. This transformative force underpins all the activities the Agency undertakes to transition novel technologies whether an exquisitely tuned laser mapping system or a simple net of armor. Experience and credibility are important to building confidence and trust with users. This is best done through active engagement and a track record of successful response under stressing conditions.

It is critical to balance our focus on today with a bold vision of tomorrow.

To catalyze the development of advanced capabilities for next-generation conflicts, we had to redouble our efforts to reach. To risk. At DARPA we say that we must not lose the nerve for the big failure. The nerve you need for the big failure is the same as the nerve for the big success, until the moment you know which it will be. It's the exact same nerve.

Just a few weeks ago, IBM's Watson supercomputer, which is designed to deal with unstructured data and to interpret natural language, beat two *Jeopardy* champions. The final tally: Watson: $77,147. Jennings: $24,000. Rutters: $12,600.

Many felt the contest was a vindication of the academic field of artificial intelligence, which as stated in *The New York Times*, "...began in the 1960s with the vision of creating a thinking machine and which became the laughing stock of Silicon Valley in the 1980s when a series of heavily financed start-up companies went bankrupt."

For decades, computer scientists have had nerve in the face of failure and even ridicule. It turned out that failing was a part of succeeding. Tenacity in the field, in execution, led to victory. Their vision, paired with execution, was realized in Watson's win.

One of the *Jeopardy* participants, Mr. Jennings, said that "I had a great time and I would do it again in a heartbeat... this is about being part of the future."

We have endeavored to revitalize this sensibility at DARPA... the Agency's willingness to take on the big risk.

We have embraced programs such as PROCEED, which is focused on accelerating recent advances in computer science that only recently produced a theoretical construction for fully homomorphic encryption. After thirty years of research and a period of time when homomorphic encryption was treated as a foundation for impossibility proofs, in 2009, Craig Gentry produced a construction that proved the opposite, indeed, that it is possible to compute on encrypted data without decrypting it.

Why does this matter? Because encryption is one of our most basic methods for protecting information. But if we want to operate on encrypted data—process it, actually do something with it—we have to decrypt it first. And it is necessarily at greater risk in the decrypted state. We operate on it while it's in a decrypted state, then take the result, encrypt it again, and send it on.

The fundamental mystery is whether it is possible to perform operations on encrypted data without decrypting it first. And even if it is theoretically possible, is it practical?

Gentry's work about a year and a half ago opened the door. He proved that it could be done. That's the good news. The bad news is, it's very inefficient right now—14 orders of magnitude less efficient than it needs to be. The first demonstration involved a simple "and" function. It took 30 minutes. A comparable computation using existing systems today would take a fraction of a nanosecond.

PROCEED is working to improve that efficiency. The program tackles a number of research areas that will be needed to successfully turn theory into practice. It seeks to develop improved mathematical foundations for fully homomorphic encryption as well as secure multiparty computation protocols. It will develop highly optimized implementations of the necessary cryptography. The PROCEED program attempts to

crack this computational challenge to develop a practical means to compute on encrypted data, even on possibly compromised computational infrastructure.

If we are successful with PROCEED, it fundamentally changes the calculus for computations in untrusted environments... on computer systems of unknown provenance. The potential implications for the cybersecurity of cloud computing architectures are profound.

Practical implementation of fully homomorphic encryption is the goal of PROCEED. Unlocking the fundamental measurement of nature is the aim of QuASAR. Quantum-Assisted Sensing and Readout seeks to develop clocks and sensors that operate at the standard quantum limit. Once these individual devices are made as 'quiet' as possible, however, the story is not over. Quantum mechanics allows one last trick: by entangling multiple sensors, we can wring out additional quantum noise to surpass the standard quantum limit.

The complexity of this goal exploits a simple idea: the best measurement devices, atomic clocks, when subjected to external stimuli might also make the best sensors.

Such advances may enable high-resolution magnetic imaging capable of resolving individual nuclear spins at the nanometer scale. Such resolving power would enable the detailed, 3D structures of biological molecules with elemental specificity in their native environment and could streamline assessment of inhibitor drugs against a virus (whether naturally occurring or engineered as a biological weapon). It could alter the landscape of small-molecule development as did x-ray crystallography, electron and atomic force microscopy.

From our support to ongoing operations to the challenge of homomorphic encryption, at DARPA, the problem is not coming up with enough good ideas... but rather choosing among them.

As we looked forward to 2012 and beyond, to the future strategic areas for DARPA, and how best to choose from among the multitude of ideas, we developed three key questions that reflect the core attributes of DARPA programs.

- Will it be game changing and have lasting impact for the Department and National Security?
- Does it require DARPA technical expertise and daring?
- How does it contribute to the balance of existing investments?

Further, each decision to apply resources comes with an opportunity cost. Today, DARPA is tackling some of the most pressing and vexing challenges facing DoD. We sought to develop a means for identifying opportunities and gaps and to balance the Department's responsibility to the present, while maintaining a commitment to the future. The Agency has begun to address these executive-level Department decisions through the technology and innovation lens enabled by its unique science and technology (S&T) perch.

National Security is a high-tech endeavor. Many of the Department's most intense challenges have deep technical roots and invoke, in addition, concepts of operations, policy, economics, and the adversary's advances. The choreography of the technical, operational, policy, and fiduciary constraints has become more important than ever. DARPA has arguably one of the highest densities of technical subject matter experts in the U.S. Government. Over the last 2 years, DARPA has used this capacity to frame these complicated issues quantitatively so as to inform complex decisions. This perspective, in turn, guides investment decisions, structures our engagement with the Services, and informs the broader decisions of the Department's senior leadership.

We call these assessments analytical frameworks.

Analytical Frameworks

Over the last 18 months, the Agency has developed several analytical frameworks. They are designed to be deeply quantitative, to reveal the essential parameters governing a decision space, and to question existing assumptions. Accessible to technical and non technical executives, the analytical frameworks are structured to ensure the Agency, and the Department, are better able to focus investments. Ultimately, these frameworks have the power to reveal areas where we are divergent with threats and technological trends and, thus, need new options. The frameworks help to create the stimulus for fundamental shifts in thinking. For preventing or creating strategic surprise.

Three of these analytical frameworks are described below: global intelligence, surveillance, and reconnaissance (global ISR); manufacturing; and cybersecurity. The perspectives and understandings revealed by these frameworks have resulted in changes in our approaches.

Global ISR

There is a near-constant complaint that we are drowning in data. So, we decided to assess exactly what this means...in quantitative terms. Essentially, if we are drowning in data, we asked ourselves, how much water? We calculated data volume as a function of sensor resolution and area coverage, and we compared the data volume required to accomplish certain operational objectives. For example, to detect strategic bombers, one needs resolution of approximately 10 m^2. Over an area the size of Reagan National Airport, this resolution results in a data volume equivalent to about 1 second of Milstar SATCOM. To detect dismounts, however, one needs resolution of approximately 10 cm^2. Over an area the size of Baghdad, this is about equivalent to a data volume equal to 1 second of US Internet traffic in 2009. Nearly five orders of magnitude—100,000 times—more data. Not surprisingly given the current conflicts,

when we plotted existing and new or planned ISR systems, there was a general trend toward higher resolution and larger fields of view.

One of two things must happen: either we must give up the target set, or we must deal with the data volume. They are linked. Obviously, we do not want to give up the target set. The only choice before us, therefore, is to develop capabilities that dramatically improve our ability to manage and use the data.

The trend set by the detection of increasingly difficult targets is driving data volume exponentially. We cannot solve this exponential problem with a linear growth in analysts. Our need is divergent from our capability. Specifically, if we examine the implications of U.S. Central Command (CENTCOM) requirements alone and a modest deployment of the new high-definition DARPA system named ARGUS-IS[3], the number of analysts required to managed the data volume created by this demand increases roughly 15 fold.

What's the solution? Counter intuitive but DARPA-like, the problem has in it the seeds of the solution. That higher resolution, wider area coverage, namely better sensors do not always worsen the problem. Indeed, as the data improves, the performance of automated systems improves. The fundamental knee in the curve cannot yet be determined *a priori*, from first principles, but empirical results suggest that better sensors give us better data. More and better data leads to better automation. Better automation enables better analysis.

As a representative example of what this means, ARGUS-IS provides video data at five times the frame rate of conventional systems. Five times the frame rate means five times more data, but it also means that an automated system tracking a dismount or vehicle gets five times as many "looks" at the target as it moves. Increasing the frame rate makes the automated tracking both more accurate and less likely to lose the track. More data leads to better automation and, ultimately, to *less* of a load on an analyst.

[3] Autonomous Real-time Ground Ubiquitous Surveillance – Imaging System

Such tracking algorithms, in concert with more accurate image analysis enabled by higher resolution, can be trained to identify and flag actions captured on video such as "digging," "unloading," and "walking." Such an advance would allow more of the existing and new ISR data feeds to be interpreted by untiring 24/7 automated analysis systems. Not by people.

These automated systems promise to free humans to do what humans do best and leave computers to do what computers do best. If successful, the combined efforts at DARPA devoted to improving this matching would imply a linear growth in analysts, by less than a factor of two, rather than the 15-fold increase envisioned using conventional approaches. Such an advance would make the user's ability to analyze the data convergent with data generation capacity. And we didn't give up the demanding target set.

Manufacturing

On February 12, 2011, *The New York Times* published an article entitled "When Factories Vanish, So Can Innovators." It challenged previously held assumptions about the ability to decouple innovation and manufacturing. Indeed, it suggested the emergence of real questions regarding the Nation's ability to be competitive in R&D when we are not making what we innovate.

At DARPA we have a shorthand for this... we say "to innovate, we must make." And further, that the connection to the Nation's defense is profound, because it is also true that "to protect, we must produce."

Norm Augustine, former CEO of Lockheed Martin and author of *Augustine's Laws*, observed that if projected to the future, current trends in the manufacturing of defense aircraft show that, by 2054, the entire Department of Defense budget would be required to purchase one fighter airplane. Quite obviously, this trend is not sustainable. It impacts the affordability, relevance, and adaptability of the Nation's defense.

We argue that just as the cost of such systems in not sustainable, we can no longer afford the time that it takes to design, develop, and field such systems. Extended design, test, evaluation, and production times for complex defense systems, oftentimes of order decade, and the resultant lack of adaptability, has become a vulnerability in and of itself. Naturally, time and cost are linked and, importantly, in an almost self-fulfilling cycle. If upon beginning a new system development effort, we anticipate a decade-long development, then it becomes necessary to encompass all the uncertainty in the threat environment projected 10 years into the future. This drives a dramatic expansion in the design envelope, the incorporation of technologies likely not yet invented, and requires robust margins for error. All these factors contribute, in turn, to increased risk, cost, and schedule difficulties.

DARPA is not a policy organization. Our charge is not the laws or regulations that may change the landscape of DoD acquisition. Rather, we argue that fundamental shifts in the technical means by which we make things could dramatically alter this landscape. By reducing the cost and time to design, test, and produce such systems, even within existing constraints, we may be able to drive increased innovation and competition by lowering the barrier to entry. This would potentially enable the Department to move from a "buy then make" to a "make then buy" strategy.

At DARPA we have focused our investment in defense manufacturing innovation, totaling approximately $200 million per year, or $1 billion over the next 5 years, on reducing the time needed to design, develop, and field. We are synthesizing and integrating these efforts so as to contribute alternative design and production methods for next-generation systems spanning ground combat vehicles to vaccine production. Of note, while the implications of the DARPA programs may also benefit the overall US manufacturing base, our activities are focused on the needs of defense.

One such effort is the Manufacturable Gradient Index Optics (M-GRIN) program. Lens and optics technology is old. Lenses augment human sight, but present optical systems and lenses can be heavy and cumbersome; indeed, the miniaturization of many

systems is limited by the optical lenses. DARPA's M-GRIN program seeks to change traditional lens and optical systems construction by collapsing multiple lenses and their assembly into a single lens using stacked polymeric layers that better manipulate light. This means that a warfighter's flip-down helmet optics might be seven times lighter. And weight savings matter to warfighters. It could also mean that the optics currently carried on a Predator could be fielded on a miniature unmanned air system – the required wingspan for equivalent optical power could potentially go from 48.7 feet to 4.25 feet. And because the M-GRIN technology is an entirely revolutionary method for lens manufacture, it means that customized, programmable, large-scale manufacturing of unique lenses is possible for the first time. Need a custom lens? Send us your bits.

Historically a major user and driver of advanced microelectronics, today the Department of Defense is a relatively low-volume customer and at increasing risk of losing access to off-shore, state-of-the-art process and facilities. The Maskless Nanowriter program at DARPA promises to contribute to the restoration of cost-effective, integrated circuit manufacturing in small wafer lots in the United States.

The program will develop a unique nanolithography tool that writes directly on the wafer without the use of present-day multimillion dollar lithography machines and mask sets. This new tool permits tight control over wafer writing (nanolithography) to ensure greater security and low-cost integrated circuit customization, which are critical to most major U.S. Defense systems. High-resolution lithography manufacturing is dominated by foreign states at present (Netherlands and Japan). The development of this unique tool at DARPA could restore the U.S. position in the supply-chain manufacturing of critical systems components for National Defense and commercial applications.

The new tool not only yields greater control over security and cost, it also increases the speed of fabrication by 100 fold over existing electron beam lithography tools. The Maskless Nanowriter is a massively parallel electron-beam lithography tool using 1 million independently controlled electron beamlets formed by a unique reflection electron beam process. The high-resolution, high-throughput Maskless Nanowriter

enables affordable fabrication of application-specific integrated circuits. And because these systems are important to the performance and security of Defense systems, our ability to produce such components is connected to our ability to protect.

Tackling one of the most vexing challenges for the Department, the Adaptive Make effort seeks to compress the design, development, and production of complex electromechanical systems by a factor of 5: from 10 years to 2 years. With implications across Defense systems, the initial target for the program is ground vehicles. Adaptive Vehicle Make (AVM) represents a portfolio of programs intended to change the fundamental approach to the design and manufacture of major Defense systems. Simply put, it will control for time first. All elements of design, test, evaluation, production, and quality control are targeted at meeting an objective line in the sand... time.

To generate systems that are technologically advanced, adaptable, and precisely suited to mission, manufacturing for Defense applications requires the production of potentially highly differentiated systems in low volumes. This is unlike commercial systems, which do not require much variety (automobile customization is dominated by small, mostly cosmetic changes) and are produced in high volumes. Reflective of this difference, the DARPA portfolio is directed at three primary and Defense-driven challenges: the development of design and verification tools that support rapid trade space exploration and the ability to probabilistically verify correctness by construction; the creation of programmable manufacturing facilities that can produce vehicles based on the verified designs; and the enabling of crowd-derived designs that seek to expand the pool of designers and innovators by 100-fold. Through a series of design competitions, the program will culminate in the production of a "first-of" infantry fighting vehicle using these advanced manufacturing methods.

Our goal, simply put, is to create breakthroughs in manufacturing that enable massive innovation, much like the breakthrough of the Internet enabled massive innovations in the communication and IT industries. The implications for controlling the cost,

adaptability, and suitability for intended purpose of our major defense system purchases are far reaching.

Cybersecurity

In a globalized world, borders and boundaries, or "edges," no longer conform to geographic lines on a map. The ability to define these new edges, from a technological perspective, has not yet evolved. Nowhere is this felt more acutely as an opportunity than in the global mindshare of democratized, crowd-sourced innovation. Nowhere is this felt more acutely as a threat than in the cyber world.

Threats in cyberspace are multi dimensional. They range from network penetration, to the provenance of the supply chain, to the role of users. The DARPA cyber analytical framework sought to quantify elements of the threat and create a context for understanding the nature of the asymmetry. This understanding is a means for reassessing our strategy.

A key attribute of the analytical frameworks is the identification of areas where we are inherently divergent with the threat. Such areas have the seeds of strategic surprise. Such divergence is an almost inherent characteristic of asymmetric threats like cyber.

One illustration of the cyber asymmetry is illustrated by the following example: In response to the diversity and evolution of malware, cyber defense has moved from simple firewalls and application proxies to more complex firewall systems. The first appearance of "security appliances" shifted toward so-called unified threat management systems, which now approach the complexity and size of entire computer operating systems.

Over the last 20 years, using lines of code as a proxy and relative measure, the effort and cost of information security software has grown exponentially—from software packages with thousands of lines of code to packages with nearly 10 million lines of

code. By contrast, over that same period, and across roughly 9,000 examples of viruses, worms, exploits and bots, our analysis revealed a nearly constant, average 125 lines of code for malware. This is a striking illustration of why it is easier to play offense than defense in cyber, but importantly, it also causes us to rethink our approach. To seek new approaches that might lead to convergence.

This is not to suggest that we stop doing what we are doing defensively. On the contrary, our existing efforts are necessary. But if we continue only down the current path, we will not converge. The analogy is similar to being in the ocean and treading water. If you stop treading water, you will drown. Treading water is necessary for survival, but if all you do is tread water, eventually you will drown anyway. It is best to build some additional options.

Informed by the above and other insights from the analysis, we assessed that DARPA had a significant role to play; so, we recruited an expert cyber team made up of individuals from diverse experiences including the "white hat" hacker community and major commercial companies, in addition to the Defense and intelligence communities. DARPA launched several new initiatives focused on novel topics such as clean slate design of resilient, adaptive, and secure hosts inspired, in part, by biological mechanisms for resilience. In addition, efforts are underway to seek assured computations on untrusted hardware and safer Internet communications in untrusted environments.

The Cyber Insider Threat (CINDER) program seeks to develop techniques for countering one of the most significant and malicious threats to military networks and systems: the cyber insider threat. Current defenses are based on network and host intrusion detection, and look for "break ins" and abnormal behavior, but do not attempt to characterize a user's mission. Single events oftentimes evade detection or are lost in a sea of false reports. However, the conduct of a mission and the resultant insider behavior is deliberate and involves a coordinated set of actions. Strategies for detecting the mission enable templating on more complex actions and "tells" that provide a cue

subject to additional screening, forensics, or heightened alerting. Together, we argue, this promises a more robust detection capability. If successful, the CINDER program will build tools and techniques that characterize user mission in a multi level security environment.

Using the defensive mechanisms of biological systems as inspiration, the Clean-slate design of Resilient, Adaptive, Secure Hosts (CRASH) program seeks to develop cyber security technologies that radically rethink basic hardware and system designs. Higher level organisms have two distinct immune systems: the innate system, which is fast and deadly, but is effective only against a fixed set of pathogens; and the adaptive system, which is slower, but can learn to recognize novel pathogens. Similarly, CRASH will develop mechanisms, at the hardware and operating system level, which may eliminate known vulnerabilities exploited by attackers. However, because novel attacks will continue to be developed, CRASH will also develop software techniques that allow it to defend itself, to maintain its capabilities, and even "heal" itself. Finally, biological systems show that diversity is an effective population defense; CRASH aims to develop techniques that make each computer system evolve over time, thus appearing unique to the attacker.

The Military Networking Protocol (MNP) program is creating architectures, protocols and network controllers to provide attribution of traffic on our military networks to improve network integrity. Currently, our network traffic is identified only by Internet Protocol address an easily falsified form of attribution that cannot be relied upon to tell us who the individual or organization actually sending the information may be. To remedy this problem, the MNP program has developed technology that has successfully attributed traffic to individual actors in a test environment of 200 devices networked at 100Mbps. In future tests, the MNP program will achieve attribution in environments of 10,000 devices networked at 100 times faster speeds.

By enforcing military user authentication, military network protocols will provide full attribution of every military device and track each device's network flows to provide full

attribution down to the individual source of bad/erroneous data or malicious activity. Prioritization schemes can be controlled by military commanders at various echelons so as to address changing mission requirements. MNP technologies will transition to Defense Information Systems Agency and the Military Services.

The Cyber Reserve Corps program is designed to develop the necessary technologies and tools to permit massive numbers of non cyber experts to participate in the defense of cyberspace. Individuals already collaborate on cyber defense through numerous blogs and message boards dedicated to issues such as diagnosing problems on computers/networks and remediating the effects of malware on popular commercial systems. These activities are facilitated through a variety of software tools; however, additional tools for detecting and diagnosing known exploits, as well as variants of known exploits, will be developed. Cyber Reserve Corps will also create technologies for generating shareable host and network log files that both preserve the privacy of user data and inform participants about new exploits. Ordinarily, this information would remain widely segmented and dispersed; the toolset and community for Cyber Reserve Corps seek to make it possible to bring together relevant information that may reveal subtle patterns of hostile activity that would otherwise go unnoticed.

Whether you believe in a war metaphor or a law enforcement model for cyber, the goals of the response are common. The Agency is investing over $250 million in cyber initiatives in 2012, a 100 percent increase over the FY 2011 cyber request. Additionally, beginning in 2012, the President's budget request includes another $500 million for cyber research over the Future Year Defense Program. An expanded level of effort at DARPA rests on an existing foundation and continuing contributions to cyber. Indeed, DARPA-developed technologies are widely prevalent in both commercial and military use, including the technology that protects all Department network connections to the Internet against denial-of-service attacks. These additional resources are focused on the development of options beyond treading water by accelerating and expanding programs in clean-slate initiatives, the defense of cyber physical systems, and the security of supply chains. They are motivated by the Agency's history of innovation and its willingness to challenge conventional wisdom.

Getting our business practices right is part of the job.

No one remembers changes in business practices that enable success because they are, quite simply, enablers... amplifying forces that allow us to achieve great things. But getting them wrong can be a significant impediment. Execution is what turns ideas into reality – the Agency must operate effectively with agility, speed, and with technical and administrative integrity.

DARPA executes a budget of nearly $3 billion as appropriated by Congress. It does so with approximately 120 program managers—a number that has been at or below this level since 1992—and a roughly equal number of Government support staff. Financial resources and lean business practices allow the Agency to pursue ideas that most dare not touch. And to do so quickly. There are no entitlements to programs or people, no captive laboratories, no immutable tenets. The Agency has what might be characterized as a "thoughtful ruthlessness" in its dogged pursuit of the best people, ideas, and output.

The breadth, urgency, and technical demands of DARPA programs are real—the capabilities being developed may literally protect the lives of our warfighters. The innovative ideas that the Agency pursues are fragile and fleeting. To protect them, you must say "yes" before "no," and the organization's business practices must be aligned with the speed and flexibility required to do so. The "no kidding, it must work" authenticity of Defense applications demands an organization dedicated to excellence in execution through all levels of management, policies, and personnel. Indeed, in the face of such pressures, creativity requires heroic intellectual leaps not just from the technical side of the organization, but equally from the support side of the organization. And such heroic leaps mean that DARPA must find the best people, the best jumpers, for all positions at DARPA.

Notably, the absence of bureaucracy is an oft-cited characteristic of DARPA. The Agency has only one layer of management between the Director and the program

managers. There are currently six offices in the Agency that comprise a dynamic and fluid construct that changes in accordance with technological and personnel opportunities. In the last year, DARPA stood up two new offices and combined two offices to the benefit of our efforts. We have support offices dedicated to essential functions that enable the mission through innovative practices that mirror the technical innovations of the Agency.

DARPA attracts some of the country's best technical minds who serve for a tour of 3 to 5 years. Program managers with technical acumen and nerve are empowered to run programs, adapting in accordance with advances and challenges. They have authorities matched to their responsibilities. Accountable to the Agency, to the Department, to the Nation, and to our warfighters, DARPA's program managers are drawn from academia, industry, nonprofits, the Services, and laboratories. Program managers, office directors, the Director, and the Deputy Director change on a regular cadence. This practice ensures the Agency is current with existing and emerging technological trends, encourages a continual challenging of bureaucracy, and imparts an ethic of urgency and delivery for all personnel.

In recent years, Congressional oversight committees have expressed concern that DARPA's financial execution was inadequate; specifically, that DARPA was not obligating a significant fraction of the money it had requested. These concerns resulted in budget cuts and rescissions, but, as well, obligation delays meant fewer resources at work for the Department. In 2010, we placed a significant emphasis on financial execution. At the end of September 2010, the Agency's obligation rate was 23 points higher (86 percent) than the 5-year average (63 percent) despite the delayed January 2010 Appropriations signing. At the end of fiscal year 2010, the improved execution translated into more than $600 million in the performer community, working for the Department and Nation.

Speed is part of the vibrancy of innovation. Consistent with these improvements in execution, the average contracting time is down by 18 percent. From proposal approval

to contract signing, the Agency took 56 days in 2010, compared to 68 days in 2009—nearly a full 2 weeks across both internal and external contracting actions, large companies and small businesses. Contracting vehicles are also being used in the best interests of cost savings. For example, the Agency saved $60 million in the renegotiation of a multi performer, high-performance computing effort through the use of a contracting method better matched to the effort and mix of performers. We streamlined decision making and simplified contracting. The process is now clear, fair and fast. Better business practices are just better Government. It affects not only the performers, but the Agency too.

The programs and ideas developed at DARPA are not ours alone. Rather, they are the result of vibrant exchange among many. One of the Agency's strengths is its ability to build bridges between disparate communities and to uncover ideas in unexpected places.

This ability to build new communities is predicated on the Agency's commitment to work at the intersection of basic science and application, so-called Pasteur's quadrant. DARPA is not a pure science organization, but neither is it a pure application organization. To be successful, we need the minds of the basic scientists and the application engineers, those in universities, and those in industry. And we need them working together, often on a single project, in the cauldron created by the urgency and technical demands of Defense. This is almost a unique characteristic of DARPA projects, which are often multidiscipline, multicommunity, and multistage. Our talent pool spans our interactions with universities, industry, the Services, among others.

Universities.

Over the last few years, the university community articulated concerns about a breach in DARPA's commitment to basic research. There was much said on both sides about the veracity of these concerns. Regardless of one's opinion about how a breach may have occurred, it was clear that one had.

Last year, we related to this committee that, upon arrival at DARPA, we were determined to understand and repair the breach. The first step was to get ground truth. We did a deep dive and discovered that indeed, between 2001 and 2008, DARPA funding to US research university performers did decrease in real terms, by about half. Many attributed the breach to that alone. But we found that it wasn't only about the money. As importantly, a noble and recent focus in the Agency on solving nearer term problems for the Department had resulted in some additional, perhaps unintended, consequences.

The nature of the work changed, from multiyear commitments to those with annual "go, no-go" decisions governing continued funding. The later stage focus also resulted in more work done by universities as subs to prime contractors responsible for integration efforts since, it was argued, the larger contractors would be more suitable for translating research to fielding. The result, however, was that the larger companies imposed restrictions on the use of foreign nationals, export control, prepublication review, among others, onto the fundamental research conducted on campus at universities. All these restrictions combined to threaten the very nature of fundamental research and, worse, at some universities, made it impossible within their acceptable contractual constraints, commitment to students, mission and culture, to contribute to the Defense mission.

The result meant the intellectual power of the academic community was not nearly at capacity in its contribution to Defense and National Security. Truth be told, though, it wasn't damaging only us. Many researchers who had historical interactions with the Agency said that DARPA performer meetings would be the ones you never missed. That the nature of funding, the community, the challenge involved in a DARPA program led by a spirited, technically uncompromising, and slightly "unreasonable" visionary program manager... well, it was just different. And it inspired them to do their greatest work. Oftentimes they spoke with a nostalgic longing for those glory days.

We need the minds of the basic scientist and the application engineer, those in universities and those in industry. And we need them working together, often on a

single project, in the cauldron created by the urgency and technical demands of Defense. Because it is almost a wholly unique characteristic of DARPA projects—the blending of basic science and authentic application. And in a way, perhaps unexpectedly, these communities need DARPA too.

That's where we stood more than a year ago. And then, we got to work.

We established protections for basic research. Under existing guidance dating back to 1965 with a National Security Decision from the White House, Directive 189, and reiterated in a DoD memo dated June 26, 2008, the products of fundamental research are to remain unrestricted to the maximum extent possible. And while there may be compelling reasons for DoD to place controls on some applied research that is performed on a university campus, such occasions should be rare and each must be carefully scrutinized.

Only a few months after our visits to universities, in January 2010, DARPA spearheaded an effort to switch the default... namely, to ensure that fundamental research protections are used in all contracts unless a waiver is secured at the Deputy Director or Director level. In 2010, the DARPA Deputy Director approved waivers for only 5 of 275 total contracts in fiscal year 2010. In all five cases, the university participants engaged in the deliberations and concurred with the restrictions imposed.

Universities are also contributing to the leadership talent pool. In the 5 years prior to 2009, the per year average number of university faculty and researchers hired to work as program managers at DARPA was two. Last year it was 10. A five-fold increase. We challenged the universities to send their best and brightest, and they did. We have professional associations, individual professors, department heads, deans, presidents and provosts to thank.

Industry.

Equally important, of course, is the role of industry, from electronics to pharmaceuticals, software to space, small businesses to large. In January and September of last year, DARPA held Industry Summits to engage the leadership of U.S. industry: chief executive officers, chief technology officers, chief operating officers, and senior vice president-level executives. More than 70 percent of the participants were from small businesses, including some who had never before done business with DoD. The outcome of the Summits was much broader than anticipated. Nearly half the participants went on to build new business-to-business connections, for which DARPA served as a bridge.

More than 200 companies so far—Defense and non-Defense, representing 16 business sectors—participated in roundtable discussions regarding how competitiveness is affected by globalization and the implications for National Security. The discussions concerned the barriers to innovation, access to science and technology talent, and Government/industry relationships. The days were long, and the discussions were animated. Perspectives were refined, discarded, shifted. We gained insight, as did the participants.

Some of those insights we have turned into action. For example, we created a Small Business Innovation Research "EZ" contracting mechanism based on commercial best practices. Contracts have gone from 50 pages to 10. Using our Other Transaction authority, the contracts permit generally accepted accounting principles accounting and streamlined reporting, as well as data rights and intellectual property language that facilitates commercialization and addresses the concerns of investors.

The result: to date the time for contract award has been reduced from a typical 5 to 6 months to less than 30 days. This change is motivated in part by the Deputy Director's and my experience in the private sector. We know that time is money and that each opportunity pursued is another one not.

By ensuring our engagements and business practices better match the pace and expectations of the commercial sector, we will also open the aperture to those who can contribute. Many potential performers who may have innovative solutions are unfamiliar or misinformed about the challenges and constraints of working with the Federal Government. Business practices that facilitate the introduction of fresh perspectives from new performers increase the likelihood that the Agency and the Department are getting the best solutions, efficiently.

In certain emerging technical areas, most notably cyber security, some of the most innovative and ground-breaking work is conducted by small nontraditional teams. We find that they are willing, even eager, to contribute to Defense and National Security, but disincentives created by traditional Federal Acquisition Regulation based contracting mechanisms and the associated reporting burdens dissuade them. Over the next year, we aim to fix it.

The Services.

DARPA's partnership with the Services might best be described as a collaborative competition. We get crosswise when either party thinks it is only a collaboration or only a competition. An appropriate analogy might be much like that experienced by athletes, where competition serves as a means of identifying winning strategies, and collaboration through agreed-upon rules and scoring is a means of honoring higher goals. We agree to this collaborative competition because it works, but it is not without its struggles.

DARPA's responsibility is to our warfighters and to the technological superiority of the Nation's Defense. We exist in part to challenge existing perspectives. We break glass. We make people excited and, admittedly, sometimes, we make them uncomfortable. This includes the very people we honor most... the men and women of the United States military. Given the nature of the Agency's activities, it is understood that some of DARPA's most important contributions to the Nation's Defense have been in pitched

opposition with established views. It would be impossible to prevent and create strategic surprise without a spirited willingness to take on the battles that ensue.

Throughout the process of transition, missteps occur on both sides. It is intensely difficult to penetrate existing systems and change prevailing views. When a new idea is outside one's worldview, it is virtually impossible to see. It is almost a hallmark brand for truly innovative work. The efforts to field stealth and unmanned aerial vehicles (UAVs) come to mind. An aircraft designed with angular shapes to control their radar cross section? An airplane without a pilot on board? Initially, both concepts met with great resistance. Persistence, demonstrations at convincing scale, visionary champions in the Services, the participation of many including other elements within the Department, and support in other branches of Government, yields success. A specific strategy for continued, substantive engagement across this spectrum helps.

Beginning in 2009, the Agency reinvigorated interactions with its primary customers, the Services. These interactions are designed specifically to highlight recent advances, clear obstacles, lay the foundation for analysis using our analytical frameworks, and better align for potential success of early research. DARPA has begun semi-annual exchanges with the Joint Requirements Oversight Council (JROC), and quarterly engagements with the Service Vice Chiefs and their senior staffs, as well as the Service Secretaries, through the Undersecretaries and chief acquisition officials. These interactions are in addition to regular engagements with the Service Chiefs, the Combatant Commands (COCOMs), the Service materiel development and science and technology organizations, among others. In addition, we support and interact with members of the Army Science Board, Air Force Science Advisory Board, Defense Science Board, and Naval Research Advisory Committee.

Importantly, we have found that the analytical frameworks, described earlier, have become central to these discussions in that they create a common ground and build a shared understanding. We have redoubled our efforts to instill credibility and frankness about the maturity and transition readiness of DARPA programs by clearly

distinguishing technologies that are in the concept, prototyping, and fielded stages. The frameworks, a spirit of openness, clarity of transition readiness, and efforts that deliver capabilities to ongoing operations, have built better and lasting bridges between the technical experts within the Agency and those in the operational community. We better understand the problems, and senior leaders are better equipped to make decisions based on gaps and opportunities. We are both able to appropriately leverage our strengths and resources.

Educate. Inspire.

The quality of the country's talent in science, technology, engineering, and math matters for the innovative health of the country. It matters not only for our economic competitiveness, but also for the Nation's Defense. Education is a necessary condition, but it is not sufficient. It opens the door, but it does not close the deal. Curiosity. Wonder. Inspiration. They matter too.

Einstein said, "The most beautiful thing we can experience is the mysterious. It is the source of all true art and all science. He to whom this emotion is a stranger, who can no longer pause to wonder and stand rapt in awe, is as good as dead; his eyes are closed."

DARPA has been creating mystery and purposeful wonder since its inception. Programs such as Big Dog, which created a decidedly life-like four-legged robot, tantalized imaginations. At last count, videos of Big Dog in action have been viewed more than 2.7 million times on YouTube. The DARPA Network Challenge, also known as the Red Balloon Challenge, made participating in a social media science experiment accessible for millions. Young and old. Scientists and poets.

But it's not just the programs. People at DARPA carry a mystique about them too. Technically astute, inspiringly articulate, full of "fire in the belly," with the skills of a doer in addition to the vision of a dreamer, the quintessential DARPA program manager

sees something that others do not yet see. And they see it so clearly, they cannot unsee it. They are hell-bent and unrelenting in their efforts to show the world what's possible.

The Gedanken exercise isn't enough for them. They aren't just curious daydreamers. They are technical visionaries that turn their visions into reality. They want to demonstrate at convincing scale... to turn impossible to improbable to inevitable. They are expert task masters, communicators, negotiators. The best are tenacious—they just don't give up. They step up to their responsibilities for S&T leadership and they do not stop at demonstrating a capability, but drive to clear the path for turning that new capability into use.

The paths are diverse and varied from the effort to field unmanned aerial vehicles in an environment that better understood pilots in the cockpit than on the ground; to creating a DARPA forward cell in Afghanistan in support of the war effort; to negotiating for a new fast track capability—the Medical Device Innovation Initiative—with the U.S. Food and Drug Administration so that wounded warriors can receive the most advanced, state-of-the-art prosthetics. Developing the technology isn't enough.

Perhaps one of the most publicly recognized programs at DARPA is the advanced prosthetics program. The goals of the Revolutionizing Prosthetics program are two-fold: to provide an arm with a range of motion and dexterity comparable to a natural arm and, eventually, to provide an arm that permits the same sensory experiences as a native limb. Motion and dexterity are enabled by a microchip on the surface of the brain that decodes neural activity into the signals to actuate and control the prosthetic, restoring near-natural arm, hand and finger function to patients suffering from spinal cord injury, stroke, or amputation. Currently, a neurally-controlled arm is undergoing qualification for its ability to restore tactile feedback to the user such that he or she can feel temperature and joint motion. We believe that, together, these features will restore functionality to the user that approximates that of their original, native limb.

Last year, I told you the story of Fred Downs, who I met first when he visited DARPA to demonstrate use of one of the new DARPA arms. Fred lost an arm in the Vietnam War and had been using a conventional prosthetic ever since. His command of the new arm was impressive. But what struck me most was the story he told of his own reaction to wearing it. He said that after a very short time, he was surprised by his sudden emotional response. Because, he realized that he was thinking like a bilateral again. For the first time in 40 years.

It was remarkable.

The program manager who made this happen is United States Army Colonel Geoff Ling. Doctorate in pharmacology from Cornell University's Graduate School of Medical Sciences. Medical degree from Georgetown University. Neurology residency at Walter Reed Army Medical Center. Research tour at Sloan-Kettering Cancer Center. Neurointensive care fellowship at Johns Hopkins Hospital. Serves on the critical care staff at Walter Reed Army Medical Center and Johns Hopkins Hospital. Credited with an innovative procedure that likely saved former Chairman of the Joint Chiefs of Staff, General Hugh Shelton, from a wheelchair after a catastrophic fall. Colonel Ling has the singular distinction within DARPA of having briefed a program from the war in Afghanistan.

Colonel Ling is widely known for his leadership, ethical standards, vision and commitment to excellence. He has had a profound impact on DARPA, our Nation's warfighters, and the medical community at large. He is a leader: on the battlefield, in an intensive care unit, or along the halls of DARPA. He takes charge of situations, asks provocative questions, and is uncompromising in his search for better. Good enough simply isn't in Colonel Ling's world.

Anyone who interacts with Colonel Ling knows... he does what he does because his internal compass points in the direction of service before self. It is what drives him. And his far-reaching programs—from Fracture Putty to Predicting Health and Disease—

are the evidence. He is credited with saving the lives of countless warfighters through his efforts at DARPA and as a doctor. He sets a standard that many of us strive to meet.

44th Medical Brigade (Airborne), MD, PhD, spirited. He's the archetypal DARPA program manager and the person to talk to if you want a little inspiration.

DARPA is committed to this archetypal program manager. Oftentimes viewed as "difficult to manage" in other organizations, DARPA is a place where their spiritedness and willingness to challenge existing opinions is valued, not "just tolerated." Truth be told, they are the inspirational force of the Agency. In a return to their classic role, program managers are once again running programs in their best judgment. They have both the responsibility and the authority to do so. Why does this matter? Because the best people come when they have the unique power to change things. And because they aren't afraid to be accountable.

Conclusion.

This last year was one of investments, risks and payoffs. From computer science to biology... from quantum sensing to infantry fighting vehicles... manufacturing to cyber... sniper fire to prompt global strike. From strategic surprises measured in 90-day Skunkworks efforts in support of ongoing operations to those likely realizable in a decade... we reinvigorated our work, challenged ourselves, and embraced mystery in big, bold DARPA strokes.

We took seriously the responsibility to use DARPA's resources effectively. We treated it as an opportunity to improve rather than a reluctant obligation. We set aggressive goals and quantitative measures of efficiency for the Agency. We used a deeply analytical approach to making our investment choices, saving or shifting focus to the most pressing Department needs. This was not change at the margins; it is a targeted investment in excess of $1billion over the coming years. As of September, improved

financial execution put $600 million more of the Agency's resources to work in the economy and against Department problems as compared to our historical 5-year average. And our time to contract award is faster by almost 20 percent. We revitalized our engagement with Universities, Industry, and the Services.

It is progress to be proud of... progress in shared service to the Nation. Progress, we hope, that is worthy of the honorable men and women in our Armed Forces. This is our way of honoring the sacrifices of the men and women of our military who, through their service, have written a blank check made payable to the United States of America for an amount "up to and including their lives."

Vision without execution is daydreaming. There is a time and a place for daydreaming... but it is not at DARPA.

Sir Francis Drake said, "There must be a beginning to every great matter. But the continuing unto the end, until it be thoroughly finished, yields the true glory."

We're not finished.

Thank you.

Regina E. Dugan
Director
Defense Advanced Research Projects Agency

Appointed by Secretary of Defense, Robert M. Gates, and announced by the Director, Defense Research and Engineering, Zachary Lemnios, Dr. Regina E. Dugan was sworn in as the 19th director of the Defense Advanced Research Projects Agency (DARPA) on July 20, 2009.

Founded in 1958 as a response to the Soviet Union's launch of Sputnik, DARPA's mission is to prevent strategic surprise for the United States as well as create strategic surprise for our adversaries. From its founding more than 50 years ago to current day, this mission implies one imperative for the Agency: radical innovation for national security. Today DARPA is the principal agency within the Department of Defense for research, development and demonstration of high-risk, high-payoff projects for the current and future combat force.

Experienced in counterterrorism and defense against explosive threats, Dr. Dugan first served the Nation as a DARPA program manager from 1996 to 2000. During this first tour with the Agency, she directed a diverse $100 million portfolio of programs including the "Dog's Nose" program, an effort focused on the development of an advanced, field-portable system for detecting the explosive content of land mines. In 1999, Dr. Dugan was named DARPA Program Manager of the Year for her efforts, and in 2000 she was awarded the prestigious Bronze deFleury medal by the Army Engineer Regiment. She is also the recipient of the Office of the Secretary of Defense Award for Exceptional Service and the Award for Outstanding Achievement.

Dr. Dugan's contributions to the United States military are numerous. She led a counterterrorism task force for the Deputy Secretary of Defense in 1999 and, from 2001 to 2003, she served as a special advisor to the Vice Chief of Staff of the Army, completing a Quick Reaction Study on Countermine for Enduring Freedom. The results of this study were subsequently briefed to joint senior military leadership and successfully implemented in the field.

Prior to her appointment as director of DARPA, Dr. Dugan co-founded Dugan Ventures, a niche investment firm, where she served as President and CEO. In 2005, Dugan Ventures founded Red**X**Defense, LLC, a privately held company devoted to innovating solutions for combating explosive threats, where she also served as President and CEO. From private industry, Dr. Dugan brings a wealth of management, finance, product development, and marketing experience to the Agency.

Widely recognized for her leadership in technology development and as an experienced public speaker, Dr. Dugan has appeared on the Discovery Channel, National Public Radio, and *The AAAS Science Report.* Her projects have been the subject of articles in *The New York Times Science Times, The New York Times Circuits, Forbes, The Wall Street Journal, Chemical and Engineering News* and *Science News.* Additionally, Dr. Dugan previously participated in wide-ranging studies for the Defense Science Board, Army Science Board, National Research Council, and the Science Foundation, and sat on the Naval Research Advisory Committee and the Defense Threat Reduction Agency and Technology Panel.

Dr. Dugan obtained her doctorate degree in mechanical engineering from the California Institute of Technology and her master's and bachelor's degrees from Virginia Tech. She is the sole inventor or co-inventor on multiple patents and patents pending. Dr. Dugan is the co-author of *Engineering Thermodynamics*, 1996. She is the first female director of DARPA.

WITNESS RESPONSES TO QUESTIONS ASKED DURING THE HEARING

March 1, 2011

RESPONSE TO QUESTION SUBMITTED BY MS. SANCHEZ

Dr. FREEMAN. The Military Photomedicine Program (formerly the Medical Free Electron Laser program) is currently funded out of the Defense Health Program line 0602115HP, and executed by the Air Force Office of Scientific Research. I understand the President's Budget Request for Fiscal Year 2012 includes $4.8 million for this effort. [See page 21.]

QUESTIONS SUBMITTED BY MEMBERS POST HEARING

MARCH 1, 2011

QUESTIONS SUBMITTED BY MR. THORNBERRY

Mr. THORNBERRY. As the Department's Chief Technology Officer it is imperative that your office understand not only of the technological capabilities and challenges across the Department but those capabilities and challenges in the private sector that directly impact the DOD and warfighter. What methods, specifically, does your office utilize to build awareness of and assess the security & integrity of critical technologies in the private sector?

Secretary LEMNIOS. As outlined in DOD Directive 5134.3, the Assistant Secretary of Defense (Research and Engineering) (ASD(R&E)) serves as the Chief Technology Officer for the Department of Defense and is responsible for "developing strategies and supporting plans that exploit technology and prototypes to respond to the needs of the Department of Defense and ensure U.S. technological superiority." Key to this responsibility is understanding the capabilities that reside in the private sector and how those could be accessed and leveraged to directly support the Department and warfighter.

At the technology level, the Department engages broadly with industry through the Small Business Innovation Research Program, contracted research programs, service laboratory engagements and participation in subject matter conferences.

At the systems level, the Department's Trusted Defense Systems Strategy, delivered to Congress in January 2010, outlines a strategic interaction with industry as one of the four major tenets of this strategy. These include:

- Object Management Group's (OMG) Software Assurance Special Interest Group (SwA SIG), which extended the Knowledge Data Model (KDM) to software assurance;
- DHS Software Assurance Program, which works with the private sector, academia, and federal entities, including my office, to encourage and enable software developers to focus on quality and security throughout the development lifecycle;
- National Defense Industrial Association's (NDIA) System Assurance Committee, which developed the "Engineering for System Assurance Guidebook;
- The Open Group's Trusted Technology Forum, which is releasing a global framework, guidelines, procurement strategies and related resources to enable the technology industry to "build with integrity" and enable customers to "buy with confidence";
- Information Communication Technology—Supply Chain Risk Management (ICT–SCRM) Ad-Hoc Working Group, under the American National Standards Institute's (ANSI) CyberSecurity-1 (CS1), is leveraging a wide range of industry participants' inputs on SCRM-related "commercially acceptable global sourcing standards" to form national positions in support of the International Standards Organization community; and
- International Council on Systems Engineering (INCOSE) System Security Engineering Working Group, which is developing design concepts, system engineering processes, standards, and community awareness for next generation system security.

The Department's Science and Technology Executive Committee (S&T EXCOM), chaired by ASD(R&E), provides a forum to integrate awareness of emerging private sector technical capabilities across the Department and accelerate their connection to the Department's needs.

Mr. THORNBERRY. As you are aware, over the past two decades several critical defense technologies have moved off-shore leaving the Department of Defense dependent on foreign competitors for key defense components and systems. What technological capabilities and/or specific technology areas are you most concerned about losing to off-shore interests over the next five to ten years?

Secretary LEMNIOS. Technology globalization has enabled many nations to access leading-edge technologies where the United States historically has enjoyed a dominant role. The Defense Production Act (DPA) of 1950 provides authority to reduce U.S. dependency on foreign sources for critical materials and technologies essential for national defense.

In the last 10 years, the DPA has funded domestic investments in 46 essential defense technologies including gallium nitride semiconductors, carbon nanotube fibers, continuous filament boron fiber and high-purity beryllium. The total investment over the past 10 years has been $677.22 million.

In particular, the DPA, Title III effort is focused on establishing production capabilities that are self-sustaining. Contractors are encouraged to focus on business planning, marketing and improvements in production capabilities. The combination of strengthened production capabilities and increased marketing efforts helps ensure the financial viability of critical industrial capabilities.

Looking ahead, I am most concerned that international markets are driving leading edge semiconductors, advanced materials, high efficiency battery technology and manufacturing tools off shore. In each of these areas, the Department is working across the Government to assess the national security impact, identify the enabling technical concepts, and outline a viable business model for Defense Production Act investment.

One of the tools available to the Government to assess the risk to these critical industrial sectors and recommend mitigation measures is the Defense Production Act Committee (DPAC). The 2009 amendments to the DPA created the DPAC, and comprises approximately 14 federal agencies. The role of the DPAC is to conduct assessments of the U.S. industrial base to identify risks within supply-chains deemed essential to U.S. national security and critical infrastructure, and prescribe means for mitigating the risks identified. The DPAC utilizes an inter-agency process, which conducts assessments to identify manufacturing activities requiring support. These assessments include analysis of supply-chains; emerging technology developments/applications; components' criticality, importance/reliability of sources; and appropriate access to capital to support urgent national requirements. The assessments also include recommendations for mitigating risks identified in the course of those assessments.

Mr. THORNBERRY. What specific steps are you undertaking to provide timely due diligence for determining if a private sector company has resident key defense technology and what steps are you undertaking to ensure that these technologies stay in country and available for DOD programs?

Secretary LEMNIOS. In DOD, the primary responsibility for ensuring that domestically-created technologies are appropriately export-controlled lies with the Defense Technology Security Administration (DTSA). DTSA administers the development and implementation of DOD technology security policies on international transfers of defense-related goods, services, and technologies. It ensures that critical U.S. military technological advantages are preserved. DTSA operates in close coordination with the Department of State, which has lead responsibility in the U.S. Government for licensing export of defense articles and defense services.

In addition, my office works closely with the Deputy Assistant Secretary of Defense (Manufacturing and Industrial Base Policy) to analyze potential mergers and acquisitions of U.S. firms by foreign interests. These analyses are provided to the Treasury Department-chaired Committee on Foreign Investment in the United States, which determines whether the transition of private sector companies and their technologies to foreign ownership would impair the national security of the United States. Each year, my office typically provides technical assessments for several dozen such cases.

Mr. THORNBERRY. In addition to activities that were devolved to the Services, what other contributions did the S&T community make, if any, to the Secretary's efficiency initiative?

Secretary LEMNIOS and Dr. DUGAN. In response to the Department's direction to identify efficiencies, DARPA identified the first four items listed below. In addition, we were directed, per the 14 Mar, 2011 Secretary of Defense Memo Titled, "Track Four Efficiency Initiatives Decisions", to implement item five below.

1. Reduce contractor service support in Information Technology and administration from 7.5% of overall budget to less than 5.4% by FY13. This recommendation has no estimated savings in personnel and an estimated FYDP savings of $58,300,000.

2. Reduce advisory studies and boards funding by 25%, by FY12 and develop a schedule to periodically review those technology advisory boards, studies, and councils that are established for specific functions to determine if they have served their purpose and, if so, disband them as early as possible. This recommendation has no estimated savings in personnel and an estimated savings of $1,300,000 FYDP savings.

3. Automate historically cumbersome and manual administrative processes to improve productivity, quality, and create efficiencies. There is an estimated FY12 savings of $295,000.

4. Expand use of the Savannah classified network workstation. Expanding Savannah to support DARPA's multiple network processing of classified information and supporting network connectivity via a single workstation will eliminate the need for multiple classified systems and minimize requirements for the physical handling of classified material. There are no estimated savings in personnel and an estimated FY12 savings of $4,400,000.

5. Reduce DARPA Total Obligation Authority across the FYDP by 5% to better align its budget with obligation rate targets. DARPA's five-year average annual obligation rate of 63%, with an improved FY10 annual obligation rate of 84% still allows a 5% reduction with minimal impact to overall quality of effort and mission execution. Annual rescissions have been common and have influenced annual obligation rates in a positive direction; without rescissions, DARPA's obligation rates would have been measurably lower, further mitigating the risk of a 5% reduction. There are no estimated savings in personnel and an estimated FY12 savings of $153,000,000.

Mr. THORNBERRY. In addition to activities that were devolved to the Services, what other contributions did the S&T community make, if any, to the Secretary's efficiency initiative?

Dr. FREEMAN. As part of the Secretary of Defense's efficiency initiative, Army S&T funding was increased by $65 million for Indirect Fire Protection Capability research in Fiscal Years (FY) 2012–2014 and reduced by $79 million in FY 2014–2016 for contractor and manpower efficiencies.

Mr. THORNBERRY. In addition to activities that were devolved to the Services, what other contributions did the S&T community make, if any, to the Secretary's efficiency initiative?

Admiral CARR. The science and technology (S&T) community complied with the Secretary of Defense's direction to reduce reliance on service contractor support by 30 percent over three years. The savings identified by this efficiency reduction were then realigned from contractor support to true S&T investment, also in accordance with the secretary's direction. Additional S&T efficiencies were identified, some of which were tied to in-sourcing contractors and detailees to government civilian positions. The non-S&T portion of the Office of Naval Research's portfolio sustained similar efficiency reductions, including reducing civilian manpower levels back to the Fiscal Year 2010 levels.

Mr. THORNBERRY. In addition to activities that were devolved to the Services, what other contributions did the S&T community make, if any, to the Secretary's efficiency initiative?

Dr. WALKER. In response to the Secretary's efficiency initiative, the Air Force Research Laboratory was tasked to identify almost $150 million in efficiencies from within the Air Force S&T Program starting in Fiscal Year 2013 and spanning the Future Years Defense Program. The resultant savings are to be reinvested back into S&T program content. Examples of efficiencies may include reductions in headquarters staff, travel, and laboratory logistics costs, as well as integration of core technical competencies and strategic planning functions across some technical directorates. The plan is for savings to be reinvested into S&T efforts supporting Flagship Capability Concepts, Technology Horizons, and other priorities. In addition, efficiency savings garnered from the Basic Research program are to be reinvested back into Basic Research efforts.

QUESTIONS SUBMITTED BY MR. LANGEVIN

Mr. LANGEVIN. Like the health of the technology workforce, the health of the DOD laboratories and research centers is a critical concern for the acquisition community. These facilities provide key research capabilities for the DOD, both in terms of concentrations of skilled technicians as well as necessary instrumentation. Labs also serve as a key indicator for the technology workforce that can be used to attract high quality researchers. Unfortunately, the poor state of much of the lab infrastructure in DOD can also serve to dispel many of the technology workforce that DOD would most like to attract into the technical staff of the labs.

1. How well do you think DOD labs compare to academic or industrial labs, in terms of the quality of their output and the quality of their infrastructure?

2. Do you believe that the DOD labs are aligned to meet the future technology needs of the Department?

3. What value do the labs provide for the DOD?

Secretary LEMNIOS. 1. I have personally visited many of the Department's laboratories and have found an extremely diversified mixture of superb talent, world-class facilities hampered by obsolete buildings and equipment. The Department's labora-

tories are an important part of the Department's Science and Technology (S&T) enterprise, which in addition to its laboratories, comprises industry, academia, federally funded research and development centers, and university affiliated research centers.

The Department's laboratories represent a unique conduit with industry to transfer the knowledge gained from our basic research investments into capabilities for our warfighters. Given the dynamic global and domestic research and development landscape that exists today, we are undertaking a systematic assessment to ensure the Department's laboratories are successful in the future in three areas:

a. Recruitment of top talent not only for traditional S&T areas but also in emerging new science areas which hold the potential for important new capabilities.

b. Access to suitable facilities which support the Department's core critical capabilities.

c. Development of effective and efficient business processes that provide value to the Department's missions and priorities, including processes to accelerate capabilities for the current war and prepare for an uncertain future.

2. We are working diligently to better align the capabilities and projects in the Department's laboratories to the future technology needs of the Department. The first important step in this process was outlining the Department's S&T emphasis areas which provide warfighters cross-cutting capabilities for the missions identified in the Quadrennial Defense Review. We have also identified emerging science areas that hold the promise for fundamentally new capabilities in the future.

3. The Department's laboratories provide captive technical depth in critical areas for the Department and a conduit to the emerging technical concepts in academia and industry. In many cases, our laboratory programs lead industry in critical areas that are too high risk for industry investment (advanced materials, dynamic propulsion, energetic). In other areas, our laboratories couple industry concepts to the needs of the warfighter (blast protection and intelligence surveillance and reconnaissance (ISR)). The laboratories' subject matter experts in mission critical areas provide the Department with early access to emerging concepts and rapid adaptability to the field.

Mr. LANGEVIN. The 2010 Joint Operating Environment Report from Joint Forces Command warns that a global energy crunch driven by "Peak Oil," the point at which global oil production enters terminal decline and demand therefore more rapidly outstrips supply, may cause international conflict, force deep cuts in U.S. defense spending, and undermine our economic growth. Do you concur with this assessment?

Secretary LEMNIOS and Dr. DUGAN. DARPA defers to ASD (R&E) to discuss "Peak Oil" because of their broad S&T perspective to include the Services.

Mr. LANGEVIN. Dr. Walker I wanted to ask about the high energy laser program that Secretary Lemnios recently moved to the Air Force's jurisdiction. How does the Department plan on executing the program?

Dr. WALKER. The three High Energy Laser (HEL) Joint Technology Office (JTO) program elements were devolved to the Air Force in Fiscal Year 2004. After the devolvement, a Memorandum of Agreement (MOA) was signed between the Office of the Secretary of Defense (OSD), the Military Services, and relevant Defense Agency Science and Technology (S&T) Executives. This MOA defines the HEL JTO management structure and the specific roles/responsibilities of OSD, the Military Services, and Defense Agencies. The HEL Technology Council, made up of these S&T Executives, provides technical oversight of the program executed by the HEL JTO. The Air Force provides administrative support to the program including development of the descriptive summaries and funds management. No HEL programs have been moved to the Air Force since 2004.

Mr. LANGEVIN. Do you see any potential challenges with this move?

Dr. WALKER. No. The management structure for the three High Energy Laser (HEL) Joint Technology Office (JTO) programs has been in place since these programs were devolved to the Air Force in Fiscal Year 2004 and is working well.

Mr. LANGEVIN. Recent news articles have reported that DARPA was in the initial stages of considering a militarized stand alone cloud architecture along with the establishment of mobile wireless hotspots to beam data to/from troops in difficult to access areas.

Dr. DUGAN. DARPA is investing in research and development of technologies that will bring secure high-data-rate capabilities to troops in difficult areas.

One potential technology is using optical beams as a transmission medium. This potentially counters the adversary's ability to intercept, spoof, or exploit data transmitted from one warfighter to another. In addition, Millimeter Wave (MMV) or secure Radio Frequency waveforms may provide additional secure transmission capabilities in unsecure and rapidly-changing environments.

QUESTIONS SUBMITTED BY MS. SANCHEZ

Ms. SANCHEZ. As you know, this committee has been very active with pushing the Department to improve its efforts to rapidly transition innovative technology. On page two of your written testimony, you state that the Department operates 10 Federally Funded Research and Development Centers, 13 University Affiliated Research Centers and 10 Information Analysis Centers that provide innovative paths for rapid prototyping. Could you briefly explain how the UARCs and IACs each provide paths for accelerating technologies? Please list and describe recent examples of technologies that were accelerated into fielding, a program of record, or commercial markets as a direct result of their efforts?

Secretary LEMNIOS. Our University Affiliated Research Centers (UARC) drive mission-specific research with deep connections to the academic community. These centers provide the Department with focused technical depth in critical mission areas. The Department's UARCs are as follows:

1. University of California at Santa Barbara: Institute for Collaborative Biotechnologies
2. University of Southern California: Institute for Creative Technologies
3. Georgia Institute of Technology: Georgia Tech Research Institute
4. Massachusetts Institute of Technology: Institute for Soldier Nanotechnologies
5. University of Texas at Austin: Institute for Advanced Technology
6. Utah State University: Space Dynamics Laboratory
7. Johns Hopkins University: Applied Physics Laboratory
8. Pennsylvania State University: Applied Research Laboratory
9. University of Texas at Austin: Applied Research Laboratories
10. University of Washington: Applied Physics Laboratory
11. University of Hawaii at Manoa: Applied Research Laboratory
12. University of Maryland, College Park: Center for Advanced Study of Language
13. Stevens Institute of Technology: Systems Engineering Research Center

UARCs provide capability to fill the intersection between universities and defense labs in specific narrowly defined areas. The following provide examples of technologies that were accelerated into fielding through two of our UARCs.

- A high resolution imaging sonar developed by the University of Texas at Austin Applied Research Laboratories UARC to provide enhanced capability for diver reconnaissance in shallow water and harbor environments. The SEAL Handheld Sonar is part of the program of record for U.S. Navy Explosive Ordnance Disposal and Naval Special Warfare, and it is incorporated in the Underwater Imaging System and the Hydro Reconnaissance and Littoral Mine Detection System.
- The Cooperative Engagement Capability (CEC) was proposed in the 1980s by the Johns Hopkins University Applied Physics Laboratory (JHU APL) UARC, and subsequently developed by JHU APL and industry in the 1990s and beyond as a program of record. CEC allows naval battle groups to engage targets that are at greatly extended ranges beyond a ship's radar horizon and targets that were previously considered difficult to detect and track. CEC serves as a major enabler of a single integrated air picture and provides the fleet with the defensive flexibility required to confront the evolving threat of anti-ship cruise and theater ballistic missiles.

Our Information Analysis Centers (IACs) provide tactical relevance through direct connection to the Warfighter, and strategic value through long term trend analysis and recommendations. They answer an immediate need, driven by the requirements of the Warfighter and acquisition community. Products such as State-of-the-Art Reports provide a detailed analysis of immediate, critical challenges, while technical inquiry services offer a direct connection to a vast network of Subject Matter Experts from across government, industry and academia. IACs meet the customers on their ground, maintaining involvement in technical communities and working with senior executives to solve the challenges of the day, while anticipating and preparing for those of tomorrow. The Department's IACs are as follows:

1. Advanced Materials, Manufacturing, and Testing Information Analysis Center (AMMTIAC)
2. Chemical, Biological, Radiological and Nuclear Defense Information Analysis Center (CBRNIAC)
3. Chemical Propulsion Information Analysis Center (CPIAC)
4. Data & Analysis Center for Software (DACS)
5. Information Assurance Technology Analysis Center (IATAC)
6. Modeling and Simulation Information Analysis Center (MSIAC)
7. Reliability Information Analysis Center (RIAC)
8. Military Sensing Information Analysis Center (SENSIAC)

9. Survivability/Vulnerability Information Analysis Center (SURVIAC)

10. Weapon Systems Technology Information Analysis Center (WSTIAC),

IACs do not conduct research but rather focus information analysis and results in specific domains. IACs facilitate transition by being on-call capabilities to focus information support-specific transition efforts as a tangible resource. These analysis centers are part of the Department's comprehensive information portal that is hosted at the Defense Technical Information Center (DTIC). As a measure of effectiveness, the ten analysis centers answered over 7,000 requests in Fiscal Year 2010 from across the Department on time critical issues ranging from assessing the risk of chemical terrorism to engineering resilient systems (supporting our Systems 2020 effort).

Ms. SANCHEZ. What is the recapitalization rate for your defense laboratory infrastructures?

Dr. FREEMAN. While we do not have the specific recapitalization rate for Army labs and RDECs, the laboratory recap rate for the Department of Defense Labs is approximately 70 years.

Ms. SANCHEZ. Where do the labs fall in priority with the rest of defense MILCON needs?

Dr. FREEMAN. The Services prioritize their MILCON needs against all current requirements with the laboratory recapitalization being considered along with the needs for airfields, barracks, hospitals, etc. Laboratory requests usually end up below the cut line.

Ms. SANCHEZ. What efforts would you recommend implementing to begin to meet lab MILCON needs in a fiscally responsible manner?

Dr. FREEMAN. As I mentioned, I am undertaking a comprehensive review of the state of the Army labs and Research, Development and Engineering Centers, both in terms of physical infrastructure and human capital. Once that review is complete, I intend to take the results and prioritize our needs across the entire Army lab complex.

Additionally, the Defense Laboratory Office within the Office of the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) is developing a two part metric which will measure building quality and building functionality for DOD laboratories. These metrics can be incorporated into our review to help us further understand our needs and how to address them in a fiscally responsible way.

Ms. SANCHEZ. How do your lab recap rates and investment levels for lab facilities and equipment compare with the DOE labs, private sector labs, and major university labs?

Dr. FREEMAN. Army S&T has no comparative data on any other facilities.

Ms. SANCHEZ. What are the potential negative impacts to lab mission and warfighter support of the deterioration of our lab infrastructure?

Dr. FREEMAN. Operations and Maintenance costs will continue to increase for certain older facilities which are needed to execute programs. Deterioration of infrastructure is an impediment to conducting world-class scientific research and engineering. Recruiting of new talent could be impacted as young Scientists and Engineers might prefer to work in a well maintained and equipped facility rather than one that is deteriorating. Repair and upkeep tasks are distractions to the workforce and prevent them concentrating on their scientific and technical work.

Ms. SANCHEZ. What is the recapitalization rate for your defense laboratory infrastructures?

Admiral CARR. The rate at which the facilities of the Naval Research Laboratory (NRL) are being replaced by new MILCON is about 700 years, a significant increase from the pre-1990's rate of about 100 years. This greatly exceeds the DON/DOD target of 67 years.

In the 10 years prior to the realignment of the MILCON process in 1993, five ONR/NRL MILCON projects were programmed. In the 18 years since 1993, three projects have been programmed.

The average age of NRL–DC facilities is 57 years. Declining annual MILCON investments are driving this situation: $12.1 M in the 1960's down to $1.0 M in the 2000's.

Ms. SANCHEZ. Where do the labs fall in priority with the rest of defense MILCON needs?

Admiral CARR. The needs of research and development do not fare well in direct competition with operational requirements, especially under a period of conflict that imposes heavy burden on the shore infrastructure that directly supports warfighting (piers, runways, etc). There are no Naval Research Lab MILCON projects remaining in the President's Budget Request for the fiscal year 2012 Future Years Defense Plan.

Of the twelve objective shore capability areas in the Navy MILCON scoring model, RDT&E is ninth on the list, behind Waterfront Ops, Airfield Ops, Utilities, and Training, and above Sailor and Family Readiness, Base Support, and Logistics & Supply.

Ms. SANCHEZ. What efforts would you recommend implementing to begin to meet lab MILCON needs in a fiscally responsible manner?

Admiral CARR. In 2008, the Naval Research Laboratory (NRL) completed a Corporate Facilities Investment Plan that provides strategic direction for the expenditure of laboratory overhead and MILCON funds to renovate spaces to meet evolving R&D needs in the 10–15 year time frame. Primarily through its investment of overhead funds, NRL has been able to maintain its status as a world-class laboratory. This approach cannot be sustained in the long term. The following two proposals are offered:

(1) *Establish a separate budget line to fund R&D MILCON needs.*

Funding levels should sustain a rate of replacement that meets the needs of naval research so that Naval Research can best meet the needs of the Navy and Marine Corps. This can be done by establishing a separate budget line for RDT&E projects. This would prevent continued deferment of RDT&E projects while maintaining competition between the RDT&E projects each year to ensure that only valid and well-justified projects are funded.

(2) *Allow Working Capital Fund laboratories to manage their own Capital Investment Program (CIP) for infrastructure revitalization.*

The CIP allows the use of "internal" (vice specific appropriated) funds to revitalize infrastructure. However, CIP authority is subject to administrative, budgetary, and statutory limitation for the purposes of dollar amount and fiscal year of availability. Legislation would be required to change this situation, but there are precedents for doing so. For example, the Postal Service and St. Lawrence Seaway Development Corporation use similar (or overhead) funds generated from sales to acquire, construct, and maintain their own facilities and property.

Ms. SANCHEZ. How do your lab recap rates and investment levels for lab facilities and equipment compare with the DOE labs, private sector labs, and major university labs?

Admiral CARR. Recent information allowing comparisons across these different communities is scarce. However, a DOD study in 1990 (prior to the change in the Navy's MILCON process) found the average age of DOD laboratory buildings was 33 years, compared to 22 years for all Government buildings and 17 for industrial R&D centers. In addition, 55 percent of all DOD R&D facilities were more than 40 years old, and the replacement cycle for the DOD R&D physical plant was over 100 years compared with 18 years for industrial R&D facilities.[1]

Now, 21 years later, the average age of NRL–DC facilities is 57 years.

Ms. SANCHEZ. What are the potential negative impacts to lab mission and warfighter support of the deterioration of our lab infrastructure?

Admiral CARR. The Naval Research Laboratory (NRL) conducts some of the most advanced research in the world, which depends on state-of-the-art, costly, high-precision equipment and facilities. Deterioration of facilities hinders the recruitment and retention of a high quality workforce, causes millions of dollars in damage to laboratories and equipment, and results in many months of delays to critical research projects while laboratories are restored. At a certain point, this deterioration of infrastructure can jeopardize the viability of NRL, which would in turn bear high costs to national security by limiting, degrading, or preventing the conduct of research and development required to meet the needs of the warfighter—NRL's core mission responsibility.

State-of-the-art facilities have been a major factor in forging NRL's record of achievement. In 2005, the Navy League's New York Council awarded NRL the Roosevelt's Gold Medal for Science, noting that, "NRL has helped make the U.S. Fleet the most formidable naval fighting force in the world" and calling it "the Government's premier defense research laboratory." In observing NRL's 75th anniversary in 1998, Norman Augustine said, "I know from experience that there are few other institutions—public or private—which have had a greater impact on American life in the 20th century, both in terms of military needs and civilian uses." And John Galvin said, "NRL is the equivalent of the most significant technology jewel in our country."

However, the needs of long-term research do not fare well in direct competition with operational requirements. In short, they are considered deferrable, especially

[1] DOD Defense Management Review, "Report of the Laboratory Demonstration Program Facilities Working Group on the DOD R&D Activity Facilities Modernization Requirements," 4 May 1990.

in a time of financial constraints. Successful innovation can save money and reduce total ownership cost. For example, NRL's corrosion control coatings reduced a three-coat painting process to a single-coat process and reduced total production time by more than 80%. The Navy estimates this will save $1.8 B over a 20-year period.

Ms. SANCHEZ. What is the recapitalization rate for your defense laboratory infrastructures?

Dr. WALKER. Recapitalization rates are no longer applicable for defense laboratory infrastructure to include the Air Force Research Laboratory. In Fiscal Year 2010, the Office of the Secretary of Defense (OSD) changed from calculating recapitalization rates in years to calculating this as a percent investment against the OSD Facility Modernization Model done only at the Service level (i.e., recapitalization rates are no longer calculated for Major Commands, installations, or separate agencies).

Ms. SANCHEZ. Where do the labs fall in priority with the rest of defense Military Construction (MILCON) needs?

Dr. WALKER. Air Force Research Laboratory (AFRL) inputs for MILCON funding are vetted each year and prioritized in conjunction with other Air Force requirements. In Fiscal Year 2007, AFRL's parent Major Command, the Air Force Materiel Command, implemented a new planning prioritization process for laboratory MILCON requirements. This process provides the AFRL Commander the ability to submit laboratory MILCON requests directly to the Command MILCON Panel. Previously, AFRL MILCON requests were submitted through the individual bases or centers where AFRL tenant facilities were located. As direct inputs under this new process, AFRL MILCON requirements have received higher prioritization leading to a greater likelihood for approval and funding than when previously prioritized against other base or center needs. This, coupled with the advantages and synergy of AFRL operating as a single laboratory, enables AFRL to better manage its infrastructure to include being a stronger advocate for its MILCON requirements. For those inputs not currently funded, AFRL will continue to clarify requirements to enable projects to better compete in future deliberations.

Ms. SANCHEZ. What efforts would you recommend implementing to begin to meet lab Military Construction (MILCON) needs in a fiscally responsible manner?

Dr. WALKER. The Air Force Research Laboratory (AFRL) currently utilizes MILCON authorities provided by Congress in Title 10, United States Code, Section 2804, Contingency Construction, and Section 2805, Unspecified Minor Construction. In the case of Section 2805, this authority is currently set to expire on September 30, 2012. Extension of this authority is recommended as it enables AFRL to construct needed facilities in support of emerging technologies and to correct deficiencies that could be life-threatening, health-threatening, or safety-threatening.

Ms. SANCHEZ. How do your lab recap rates and investment levels for lab facilities and equipment compare with the Department of Energy (DOE) labs, private sector labs, and major university labs?

Dr. WALKER. The Air Force Research Laboratory (AFRL) does not track or generally have access to the recapitalization rates and facilities/equipment investment levels for DOE, private sector, and major university labs. In addition, as of Fiscal Year 2010, recapitalization rates are no longer applicable for defense laboratory infrastructure to include AFRL.

Ms. SANCHEZ. What are the potential negative impacts to lab mission and warfighter support of the deterioration of our lab infrastructure?

Dr. WALKER. Existing Air Force Research Laboratory (AFRL) infrastructure is basically sound and there are no significant barriers that disproportionally impact Science and Technology (S&T) facilities on any given base. In those cases where limited installation Sustainment, Restoration, and Modernization funds are not available for laboratory requirements due to other competing priorities, S&T funding can be and is used to fund these requirements if the impact of not funding them is deemed significant. S&T funds will only be used if the work is in direct support of the S&T mission in accordance with guidance established in Air Force Instruction 65–601, Volume 1, dated March 3, 2005, Section 13B—*Funding to Acquire Research and Development (R&D) Facilities and Install R&D Equipment.* In those cases where new or unique laboratory facilities requiring Military Construction (MILCON) funding might be needed, the development of new technologies to support the warfighter could potentially be delayed if these facilities are not funded. However, this factor is taken into account as AFRL needs are prioritized against other Air Force needs during the MILCON prioritization process.

QUESTIONS SUBMITTED BY MR. JOHNSON

Mr. JOHNSON. Please explain why the OSD HBCU/MI Program was devolved to the Army and how that change promotes efficiency if the budget request is unchanged?

Secretary LEMNIOS. The Secretary's Fiscal Year 2012–2016 efficiency initiatives focused on a reform agenda to improve the Department's business operations. Specifically, the Secretary directed a series of initiatives designed to reduce duplication, overhead, and excess, and instill a culture of savings and restraint across the Department of Defense.

The Office of the Secretary of Defense (OSD) Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) Program was devolved to the Army as an efficiency measure and to streamline program execution currently being performed by the Army. OSD Assistant Secretary of Defense (Research and Engineering) will continue to provide strategic leadership of the HBCU/MI program. This devolvement will reduce transaction costs for the daily financial management and administration of the HBCU/MI budget. While the anticipated annual savings to the Department is $75,000 which is modest, this will align the program execution to the Military Department that is performing the work.

This action met the intent of the Secretary's efficiency objectives for identifying a more cost effective and streamlined business processes.

Mr. JOHNSON. Please explain how devolving this program and other programs devolved from OSD under the FY 2012 budget request saves dollars for the Department and why these programs were selected for devolution versus other programs in ASD(R&E) that were not devolved and remain in OSD?

Secretary LEMNIOS. The Secretary's FY 12–16 efficiency initiatives focused on a reform agenda to improve the Department's business operations. Specifically, the Secretary directed a series of initiatives designed to reduce duplication, overhead, and excess, and instill a culture of savings and restraint across the Department of Defense.

The OSD Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) Program was devolved to the Army as an efficiency measure and to streamline program execution currently being performed by the Army. OSD ASD(R&E) will continue to provide strategic leadership of the HBCU/MI program. This devolvement will reduce transaction costs for the daily financial management and administration of the HBCU/MI budget. While the anticipated annual savings to the Department is $75,000 which is modest, this will align the program execution to the Military Department that is performing the work.

The criteria used to select devolved programs, to include the OSD HBCU/MI program, consisted of:

1) Programs where OSD ASD(R&E) transfers full program funding (via sub-allocation) directly to a Component for program execution,

2) Identifying areas for improving and streamlining the financial management and administration processes of select programs, and

3) Identifying potential cost savings associated with streamlined business processes of select programs.

This action met the intent of the Secretary's efficiency objectives for identifying a more cost effective and streamlined business processes.

Mr. JOHNSON. In your written testimony you mention that your strategy for science, technology, engineering and mathematics (STEM) outreach includes developing a diverse talent base. Divesting yourself of the leadership responsibility for the HBCU/MI funding stream seems counter to that objective. What were your selection criteria or justification in transferring the OSD HBCU/MI Program and divesting yourself of the leadership responsibility, commitment, and visibility that is the OSD ASD(R&E) role under 10 U.S.C. 2362?

Secretary LEMNIOS. The Secretary's FY 12–16 efficiency initiatives focused on a reform agenda to improve the Department's business operations. Specifically, the Secretary directed a series of initiatives designed to reduce duplication, overhead, and excess, and instill a culture of savings and restraint across the Department of Defense.

The OSD HBCU/MI Program was devolved to the Army as an efficiency measure and to streamline program execution currently being performed by the Army. OSD ASD(R&E) will continue to provide strategic leadership of the HBCU/MI program. This devolvement will reduce transaction costs for the daily financial management and administration of the HBCU/MI budget. While the anticipated annual savings to the Department is $75,000 which is modest, this will align the program execution to the Military Department that is performing the work.

The criteria used to select devolved programs, to include the OSD HBCU/MI program, consisted of:

4) Programs where OSD ASD(R&E) transfers full program funding (via sub-allocation) directly to a Component for program execution,

5) Identifying areas for improving and streamlining the financial management and administration processes of select programs, and

6) Identifying potential cost savings associated with streamlined business processes of select programs.

The OSD ASD(R&E) and Deputy Assistant Secretary of the Army for Research and Technology are both committed to ensure the HBCU/MI strategic program goals and objectives are achieved.

Mr. JOHNSON. Can you assure the committee that no funds for the HBCU/MI in the Future Years Defense Program will be reprogrammed or transferred for other purposes?

Secretary LEMNIOS. The Deputy Assistant Secretary of the Army for Research and Technology and I are both committed to ensure the HBCU/MI program's strategic goals and objectives are achieved. Funds available for the HBCU/MI program will be executed with this intent. We are committed to preserving the HBCU/MI program funding identified in the Department's Future Years Defense Program.

Mr. JOHNSON. As consumers of the Test and Evaluation (T&E) within the DOD, do you see the T&E infrastructure keep up with the demands of S&T? Are there capability gaps in the T&E community, in terms of infrastructure and trained personnel that hinder the ability of the S&T community to transition programs?

Dr. FREEMAN. S&T does not generally require extensive use of T&E infrastructure or personnel in its efforts and as such I am not aware of any capability gaps that currently exist, nor am I aware of any current issues with T&E infrastructure shortfalls hindering S&T transitions. It is possible that future integrated technology demonstrations may require selective upgrades of T&E infrastructure and equipment, but that would have to be determined on a case by case basis.

Mr. JOHNSON. As consumers of the Test and Evaluation (T&E) within the DOD, do you see the T&E infrastructure keep up with the demands of S&T? Are there capability gaps in the T&E community, in terms of infrastructure and trained personnel that hinder the ability of the S&T community to transition programs?

Admiral CARR. As part of the Department of Defense Reliance Process, the T&E community engages the science and technology community to identify evolving technologies and the capability to test them using existing infrastructure, or to indentify gaps that require investment to allow adequate transition of those technologies. Currently there are no identified gaps requiring near term investment, but there are technologies such as lasers, hypersonic and autonomous vehicles that are being evaluated to assess current T&E infrastructure to test these technologies.

Mr. JOHNSON. As consumers of the Test and Evaluation (T&E) within the DOD, do you see the T&E infrastructure keeping up with the demands of Science and Technology (S&T)? Are there capability gaps in the T&E community, in terms of infrastructure and trained personnel that hinder the ability of the S&T community to transition programs?

Dr. WALKER. Generally, T&E infrastructure, including trained T&E personnel, meets the demands of S&T. For example, our wind tunnel testing infrastructure is sufficient to meet the demands of emerging "technology-enabled capabilities." One exception to this in the future may be in the area of hypersonics. Our ability to test hypersonic propulsion systems is barely adequate. Specifically, we cannot test full mission profiles in a single test facility with correct dynamic pressures and temperatures at this time. However, we are planning to develop a full mission profile capability over the next several years. Similarly, our ability to perform broad electromagnetic, full system testing on our national flight test ranges, to include testing of net-centric operations, is currently constrained. This is mainly due to encroachment of surrounding communities on our national test ranges, constraining our ability test our full performance capabilities in flight.

Mr. JOHNSON. As consumers of the Test and Evaluation (T&E) within the DOD, do you see the T&E infrastructure keep up with the demands of S&T? Are there capability gaps in the T&E community, in terms of infrastructure and trained personnel that hinder the ability of the S&T community to transition programs?

Dr. DUGAN. DARPA finds that the infrastructure and experience of the personnel generally are sufficient to meet our T&E requirements.

While transitioning programs have not been severely limited by T&E capabilities, there are some capability gaps that concern us. The courses of action or implications for addressing these gaps have been evaluated against other priorities or means for achieving the desired outcome.

1. Hypersonic Test Facilities. DOD T&E and NASA leadership have indicated that the wind tunnel complex at White Oak, MD and similar NASA hypersonic test facilities are scheduled to be mothballed as part of efficiency and cost saving measures. Similarly, our other existing test range facilities are in large part antiquated and not suited for long range hypersonic testing.

2. Urban Operations. The evaluation of Intelligence, Surveillance & Reconnaissance (ISR) and other types of surveillance technologies in an urban environment is hampered by the lack of an existing facility.

3. Integrated airspace for Unmanned Air Systems testing. Unmanned Air Systems (UAS) require coordination and approval from the Federal Aviation Administration to operate outside of protected airspace. With the growth in UAS across the DOD, scheduling time to perform T&E within protected airspace is becoming more challenging.

4. Cyber Testing. The ability to test cyber technologies is limited in that for any specific test, significant resources are required to build out, configure, and restore a range that can properly emulate the desired operational environment and security classification level(s) for that test.

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