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HEARING

ON

NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2011

AND

OVERSIGHT OF PREVIOUSLY AUTHORIZED PROGRAMS

BEFORE THE

COMMITTEE ON ARMED SERVICES HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

SECOND SESSION

TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE HEARING

ON

BUDGET REQUEST FOR DEPARTMENT OF DEFENSE'S SCIENCE AND TECHNOLOGY PROGRAMS

HEARING HELD
MARCH 23, 2010

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[There were no Questions submitted post hearing.]

FISCAL YEAR 2011 NATIONAL DEFENSE AUTHORIZATION ACT—BUDGET REQUEST FOR DEPARTMENT OF DEFENSE'S SCIENCE AND TECHNOLOGY PROGRAMS

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE,
Washington, DC, Tuesday, March 23, 2010.

The subcommittee met, pursuant to call, at 2:44 p.m., in room HVC–210, Capitol Visitor Center, Hon. Mike McIntyre presiding.

Mr. MCINTYRE. [Presiding.] Good afternoon. I am Mike McIntyre from North Carolina, vice chairman of the Subcommittee on Terrorism. In the interests of honoring your time, I have been asked to go ahead and convene the meeting. I think the Chairwoman, Ms. Sanchez, will be here shortly. But we welcome the witnesses today. Because of the voting schedule, in the interests of time, we would like to go ahead and proceed with your testimony. She may have an opening statement, which we will certainly honor when she comes, but in the meantime, we welcome our distinguished panel.

And here comes Madam Chairman as we convene.

OPENING STATEMENT OF HON. LORETTA SANCHEZ, A REPRESENTATIVE FROM CALIFORNIA, CHAIRWOMAN, TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE

Ms. SANCHEZ. [Presiding.] First of all, let me thank Mr. McIntyre for so ably opening this session, and also to my colleague to the left of me right now, but typically to the right, for representing the Republicans in this hearing today.

I would like to welcome you all and thank you for joining us today to receive testimony on the Department of Defense's [DOD] science and technology [S&T] policies and for the fiscal year 2011 budget request for the S&T programs within the Office of the Secretary of Defense.

The Department's S&T program supports Defense requirements for superior future warfighting capabilities by developing needed technology enhancements as well as rapidly transitioning critical technologies to our warfighter, interagency, and international partners, and the industrial base. I hope you gentlemen and ladies can tell us in real English everything that you have got planned.

Over the last couple of years, Secretary Gates has challenged the old business and operational paradigm of the Department of Defense that was developed during the Cold War. And in a strategic environment in which the United States will continue to prosecute persistent hybrid threats while simultaneously dealing with larger

near-peer competitors, as well as the myriad of unconventional and irregular threats, this S&T Department enterprise must be responsive and robust enough to hedge against uncertainty. The S&T investment should be flexible and balanced to address emerging challenges such as cyber warfare, force protection and energy, as well as breakthroughs in long-established areas like medical technology, platform survivability and sustainability, ISR [Intelligence, Surveillance, and Reconnaissance], and environmental remediation.

Not only must these investments maintain our technological superiority, but it must also fund innovative ways to rapidly field these technologies at affordable prices.

So the DOD laboratory system and the scientific workforce has traditionally kept the United States at the forefront of technological advances. But as we have seen in the last few years, some would say that we have fallen behind. DOD senior officials have testified that the Department's science and engineering workforce has experienced an attrition of more than 13,000 personnel over the last 10 years, while the demands for that same workforce are projected to increase by over 10 percent in the next 5 years.

And I know that we are doing a lot with STEM [science, technology, engineering and math] and other issues to try to get the next generation up, but we are really at that place where we need to think about who do we have, what can we have, and where do we go from here. And let's fund it correctly. So a solid S&T base is not only a prerequisite for remaining a strong military, but I think it is an absolute necessity for our Nation's security.

So today we have five witnesses before us who represent key leaders in the Department of Defense, who are responsible for discovering, developing, engineering, and fielding innovative technologies that give our warfighters that capability edge.

First, we have the Honorable Zachary Lemnios, who is the Director of Defense Research and Engineering [DDR&E] for the Department of Defense; along with Dr. Thomas Killion, Deputy Assistant Secretary of the Army for Research and Technology.

We have Rear Admiral Nevin Carr, Jr., Chief of Naval Research and Director of Test and Evaluation and Technology Requirements; Dr. Steven Walker, Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering; and Dr. Regina Dugan, Director of the Defense Advanced Research Projects Agency, or DARPA.

Once again, I would like to thank all of our witnesses for being here today, and I look forward to hearing your testimonies. And of course our very able members, my colleagues, will have many questions for you.

[The prepared statement of Ms. Sanchez can be found in the Appendix on page 29.]

Ms. SANCHEZ. And I would like to now yield to my Ranking Member from Florida, Mr. Miller, for his opening statement. Thank you.

STATEMENT OF HON. JEFF MILLER, A REPRESENTATIVE FROM FLORIDA, RANKING MEMBER, TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE

Mr. MILLER. I thank you for yielding and thank you, gentlemen, and Dr. Dugan, for being here today. I do want to say that this subcommittee did hold a hearing in May of last year on science and technology investments. And I was concerned, expressed concern at that time because of the Secretary's decision to reshape the investment priorities of the Department, because we had the 2010 budget, but we didn't have a QDR [Quadrennial Defense Review]. Now we have them both, but I still remain concerned as to where we are going, as the Chairwoman has also said, in regards to the expenditure.

And Secretary Gates is maintaining, as I understand, a focus on 6.1 and 6.2 investments. These basic and applied research areas are, as I feel, the building blocks of leap-ahead technologies and capabilities that our military is going to be using more and more as we proceed down this road over the next decade. So they certainly do need to be a part of our military strategy.

I have a full statement that I would like entered into the record. But in view of time, I would like to just ask unanimous consent that it be entered into the record.

Ms. SANCHEZ. So ordered. Again, thank you to my ranking member.

[The prepared statement of Mr. Miller can be found in the Appendix on page 32.]

Ms. SANCHEZ. And I think we will start with the testimony. I will remind our witnesses that we would like to have you summarize your written testimony. All of it is in front of us. And I am sure that some of us got to read this, at least part of it, if it was turned in on time.

And I will start with Secretary Zach Lemnios for your five minutes or less.

STATEMENT OF HON. ZACHARY J. LEMNIOS, DIRECTOR, DEFENSE RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE

Secretary LEMNIOS. Good afternoon, Chairwoman Sanchez, Ranking Member Miller, and subcommittee members. I would ask that my written testimony be entered into the record. Thank you for the opportunity to tell you about the important work the dedicated men and women in the Department Research and Engineering enterprise perform every day to ensure our Nation's security. The enterprise is strong. It includes 67 DOD laboratories disbursed across 22 States, with a total workforce of 61,400 employees, 35,000 of which are degreed scientists and engineers who publish thousands of reports in peer-reviewed technical papers, keeping the Department at the forefront.

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. Their success would not have been possible without Congress' help. And you have our heartfelt thanks for your steadfast support of our program.

From my vantage point as the Department's chief technology officer, I see us in a period of significant change brought about by a global world that is fast paced, technically connected, and remarkably innovative. The research and engineering enterprise is transforming itself to meet the challenges of this new era.

Innovation, speed, and agility—these are more important today than at any time in history. And nowhere is this more true than in how we deliver capabilities to our warfighters. For decades, the Department could rely on a long-term development model that produced the underpinning technologies that led to impressive capabilities such as stealth aircraft, precision weapons, and reconnaissance and positioning satellites.

However, today this linear development approach must be augmented by a parallel and equally robust development process that will deliver capabilities along commercial timelines of weeks and months. This is particularly true for cybersecurity, where innovation occurs rapidly and we need to stay well ahead of the threat.

The fast-paced world creates new challenges, but also new opportunities. It has led to a renewed role of the Department's science and technology programs. We are energized to quickly provide innovative new technical ideas across the spectrum of operations to fulfill the Secretary of Defense's goal to take care of our people, rebalance the Department's programs to fight the wars that we are in, while preparing for the future and reform how and what we buy. Detailed examples of this work are in my written testimony and in the testimony of my colleagues that you will hear today.

The Department's research and engineering efforts are well coordinated, they are connected with our forces on the front lines. I visited the combatant commanders and am pleased to report that we are working together, soldiers and technologists, in new ways to out-innovate those that challenge our Nation's security.

To focus our efforts, I have set four imperatives for the enterprise:

They are, first, to accelerate the delivery of technical capabilities to win the current fight. Innovation such as what we are doing with Congress' support to deploy within months new survivability capabilities for our helicopters in Afghanistan is the new norm. We have also reduced the time it takes to move an innovative idea from first principle to concept from up to 60 months to 12 months or less in our Joint Concept Technology Demonstration program.

Second, prepare for the uncertain future. Again, with your help we are increasing our basic research accounts by nearly ten percent to increase the feedstock of future capabilities. We have also proposed a new Cybersecurity Research Initiative of $200 million over 5 years to ensure our forces have the capabilities to survive and operate successfully in the increasingly important information domain.

Third, reduce the cost, acquisition time, and risk of our major Defense acquisition programs. This was the underpinning of the Weapons System Acquisition Reform Act that was passed about a year ago and we are actively engaged upon.

And fourth, we strive to develop a world-class science, technology, engineering and math capability for the Department and for the Nation, to assure that we have scientists and engineers that

can support national security initiatives 5, 10, 15, and 20 years from now. With these initiatives and with your support, I intend to further strengthen the contributions research and engineering can make for the Department's success in the years ahead.

Madam Chairwoman, thank you for my opportunity to present these ideas today in these brief remarks, and I look forward to your questions.

Ms. SANCHEZ. I thank the Director.

[The prepared statement of Secretary Lemnios can be found in the Appendix on page 34.]

Ms. SANCHEZ. I will just let my colleagues know that in about an hour's time it looks like we will have votes, and they will go on for a full hour. So we are going to try to get everything in. Again, if the witnesses will adhere to the five-minute rule.

And I will also let Mr. Murphy of New York know that I will give him my time, so he will be the first one to ask questions if he sticks around. Dr. Killion, please.

STATEMENT OF DR. THOMAS H. KILLION, DEPUTY ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH AND TECHNOLOGY, U.S. ARMY

Dr. KILLION. Thank you, Madam Chairwoman. Mr. Miller and other distinguished members of the subcommittee, I appreciate the opportunity to be here today to discuss the Army's fiscal year 2011 science and technology program and budget and the significant role that S&T plays in supporting the Army's most precious asset: That is our soldiers.

I have submitted a written statement for the record and ask that it be accepted for the record.

I want to thank the members of this committee for your important role in supporting our soldiers who are at war today, and for your advocacy of the Army's S&T investments that will sustain technological preeminence for our future soldiers. Your continued support is vital to our success.

The Army's S&T investment strategy is shaped to foster innovation while we accelerate and mature technologies that enable future force capabilities and exploit opportunities to rapidly transition technology to the current force. The S&T program retains flexibility to be responsive to unforeseen needs identified through current operations, and we have rapidly responded to a broad range of needs by leveraging our technology investments in future capabilities and our workforce expertise to address emerging issues.

Our major investments in the core S&T program are best understood in terms of technology areas. In my written testimony I detail five of those areas.

I would like to take this opportunity to talk specifically about two major new investments we are making in fiscal year 2011, as well as some of the important work that we are doing in medical research and in ongoing basic research. As you know, the United States military's deployment in Afghanistan is increasingly reliant on smaller, remote bases, often integrated within or nearby local communities. Providing force protection for these types of bases poses unique challenges.

The Army S&T community is leading a Deployable Force Protection Initiative on behalf of the Department of Defense to address these challenges, with an additional investment of nearly $170 million over fiscal years 2011 through 2015. This effort is focused on providing integrated, interoperable and scalable base protection capabilities, including stand-off detection, ballistic protection, and fire and defensive solutions. With this additional investment, Army S&T is spending approximately $250 million over that same period on technologies to protect our troops as they deploy around the world.

Our investments in C4ISR [command, control, communications, computers, intelligence, surveillance and reconnaissance] technologies are essential for maintaining comprehensive situational awareness, effective allocation of resources, and supporting rapid decision-making in the challenging environments we face in irregular warfare.

For fiscal year 2011, the Army is making significant new investments in Infrared Focal Plane Array technology. Again, the Army's S&T community has been asked to lead this Focal Plane Array Initiative on behalf of the Department of Defense. In fiscal years 2011 to 2015 the Army's Focal Plane Array Investment is increased by $94 million, to result in an overall investment of over $160 million in the next 5 years to develop critical applications for targeting, persistent surveillance, 360-degree day/night situational awareness, and high-definition night vision. This focused investment ensures the United States' preeminence in this technology area and continued dominance on the battlefield.

Our investment in medical S&T provides the basis for maintaining the physical and mental health of soldiers, as well as enhancing their performance. Investments in this area improve health protection, treatment, and life-saving interventions for our soldiers. Of particular note is the Army's investment in regenerative medicine. This research seeks to discover better ways to prevent and treat damage due to burns and to develop methods that will allow the regeneration of nerve, bone, and muscle tissue in those soldiers who have suffered serious tissue loss. This capability has great potential for treating military personnel with disfiguring and disabling injuries.

While much of our focus on S&T is necessarily on the near- and mid-term future, we have also sustained our commitment to basic research with paradigm-shifting capabilities that will change the battlefield for the future.

In closing, I would like to thank you, Madam Chairwoman, and the rest of the subcommittee for the opportunity to testify regarding the Army's S&T program and for your continued support for the technologies that will enable our soldiers both today and tomorrow. Thank you.

Ms. SANCHEZ. Thank you, Doctor.

[The prepared statement of Dr. Killion can be found in the Appendix on page 53.]

Ms. SANCHEZ. Now we will hear from Rear Admiral Carr, Jr.

STATEMENT OF REAR ADM. NEVIN P. CARR, JR., CHIEF OF NAVAL RESEARCH, DIRECTOR, TEST AND EVALUATION AND TECHNOLOGY REQUIREMENTS, U.S. NAVY

Admiral CARR. Thank you very much, Madam Chairman, Mr. Miller, members of the committee. It is an honor to report on the Department of the Navy's science and technology and how the President's fiscal year 2011 budget supports the Navy and Marine Corps.

The fiscal year 2011 budget requests $1.96 billion for Naval S&T: naval, for both Navy and Marine Corps. To support a Navy and Marine Corps capable of prevailing against any threat, ONR [the Office of Naval Research] must focus on S&T that provides the biggest future payoff, be innovative in our business practices, and improve constantly our ability to transition S&T to programs and to the fleet.

S&T highlights include development of novel man-machine interfaces, autonomous systems that separate warfighters from hazards, and increased mission effectiveness. This emphasis on autonomy and unmanned systems is embedded throughout the S&T portfolio. Technologies to reduce total ownership costs and improve system performance are also embedded across our S&T portfolio. By reducing costs while improving training and skill maintenance, S&T contributes to affordability in acquisition throughout the life-cycle of systems and platforms.

ONR continues to invest in technologies to increase energy efficiency, enhance platform endurance, and reduce dependence on fossil fuels. These efforts directly support the Navy's energy strategy and the Secretary of the Navy's energy goals.

We tend to focus on programs, but we face another S&T challenge. When Congress established the Naval Research Laboratory after World War I and ONR after World War II, the U.S. was the undisputed leader in world S&T. But that landscape continues to change, and we must keep a close watch on S&T in the international environment.

This isn't new. Our London office was created to keep an eye on European S&T in 1946. We have also established offices in Tokyo, Santiago, Singapore, and recently in Prague. We search the globe for emerging research and technologies that enable ONR to more effectively address current U.S. naval needs and future requirements, and, importantly, to avoid technological surprise.

Our efforts are coordinated with the other services and with DDR&E. Our partnership with DDR&E and the other services is critical. We are all challenged to accelerate the fielding of new capabilities, prepare for an uncertain future, in part through fusing an avalanche of data into an advantage in decision-making, do a better job of moving S&T into acquisition programs with less cost, time, and risk, and continue to develop the world-class science, technology, engineering, and math education required by our country and the Department of Defense.

I have discussed ONR's contribution to these efforts in my prepared testimony. In short, we 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 services and government organizations, including the

Departments of Agriculture, Energy, and the National Science Foundation.

We have S&T partnerships in 70 countries, all 50 States, 900 academic institutions, 1,000 points in industry hiring about 3,000 principal investigators, and under them, about another 3,300 Ph.D. students.

While the majority of our investments are with performers outside the Navy's R&D [Research and Development] system, we continue to nurture world-class skills and innovation in our own labs, and especially at the Naval Research Laboratory [NRL]. The talent resident at NRL is especially precious. We recently retired Dr. and Mrs. Jerome Karle, who came to NRL from the Manhattan Project back in the 1950s and, together, represented over 120 years of combined government service. While at NRL, Dr. Karle was awarded the Nobel Prize in chemistry. Talent like that is hard to replace.

The support of this committee has been especially critical in providing us the tools we need to build and nourish S&T in the workforce. Thank you very much for that.

My deputy behind me, Marine Corps Brigadier General Bob Hedlund and I believe our S&T investments are sound, they represent careful stewardship of taxpayer dollars, and will significantly enhance the safety and performance of our warfighters today and in the future. Thanks very much for your support, and we look forward to answering your questions.

Ms. SANCHEZ. Thank you, Admiral.

[The prepared statement of Admiral Carr can be found in the Appendix on page 62.]

Ms. SANCHEZ. And now we will hear from Dr. Walker.

STATEMENT OF DR. STEPHEN 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. Thank you, Chairwoman Sanchez, members of the subcommittee, and staff. I am pleased to have the opportunity to provide testimony to you today on the fiscal year 2011 Air Force science and technology program. The Air Force S&T program provides the critical capabilities, global vigilance, global reach, and global power necessary to prevail in today's complex and uncertain security environment.

At approximately $2.2 billion, the fiscal year 2011 President's budget request for S&T includes an increase of $12 million from last year. This investment sustains a strong foundation of basic research, applied research, and advanced technology development, to obtain a balance between the near-term capability support and revolutionary technologies that address far-term warfighting needs.

The Air Force continuously strives to effectively and efficiently allocate its S&T resources to provide the warfighter with superior air, space, and cyberspace capabilities, and ensure the technological superiority that is the centerpiece of our Air Force heritage.

I would like to take a minute to introduce myself to the committee, since this is the first time testifying before you. I became the Air Force S&T exec just last month, but I am not new to the Defense S&T world. I began my career at the Air Force Research

Lab in Dayton, Ohio, where I spent ten years working on hypersonics and airframe propulsion integration technologies. After receiving a Ph.D., I transferred to AFOSR [the Air Force Office of Scientific Research], where I ran a 6.1 basic research program, and then went on to serve as special assistant to DDR&E in the Pentagon. Former DARPA Director Tony Tether asked me to come over. And I have spent the last seven months working for Dr. Regina Dugan. And it has been a pleasure.

In my short time as the Air Force S&T exec, I have worked closely with the new commander of Air Force Research Lab, Major General Ellen Pawlikowski, to ensure the Air Force S&T program is postured to support the Air Force strategic priorities. We stood up an Air Force S&T tiger team with members from across the Air Force S&T products center and MAJCOM [Major Command] communities to develop a new strategy and a new S&T planning process that better aligns our S&T capability concepts with our service corps function, warfighter needs for the future.

The Air Force S&T program does a very good job at creating knowledge, applying that knowledge to develop advanced technologies, and then transitioning those technologies to industry and our acquisition product centers. I believe we need to do a better job in the future of integrating those advanced technologies and develop and demonstrate desired warfighting capabilities. And we will certainly work with others like DARPA, the services, and NASA [the National Aeronautics and Space Administration] to help realize that vision.

The current Air Force S&T fiscal year 2011 President's budget already supports several of our service corps function areas. And I would just like to talk about one or two.

The Air Force is working with DARPA to develop technologies that will culminate in the demonstration of an electric laser on a large aircraft. It is really built around DARPA's HELLADS [High Energy Liquid Laser Area Defense System] laser device. After HELLADS is complete, the Air Force will couple it to a beam control system for a series of ground demos, followed by the integration of a system module into a B–1 aircraft. ELLA [Electric Laser on Large Aircraft], the program name, will be used to demonstrate aircraft self-defense capabilities of a high-energy electric laser in a practical platform.

To achieve S&T objectives like this and others requires a vibrant science and engineering workforce and a healthy lab environment in which to work. The Air Force S&T program is committed to developing and caring for over 3,000 scientists and engineers. This commitment is reflected in the utilization of various flexibilities afforded the Air Force under the Laboratory Personnel Demonstration Project and other workforce development initiatives.

Our fiscal year 2011 budget proposal enables us to recruit, develop, mentor, and retain the best and brightest scientists and engineers. And our budget request allows us to develop the workforce of the future through a myriad of science, technology, engineering, and mathematics outreach programs and initiatives.

One I am particularly excited about is Air Camp in Dayton, Ohio, which maybe I will have a chance to talk to you about. In addition, the Air Force is using the authority provided by section 219 that

enables laboratory directors to use up to three percent of the funds available to them for discretionary efforts in support of military missions. And we are particularly happy with the lab revitalization and recapitalization part of that authority that was passed in 2010. It allowed us to improve our facilities.

In conclusion, the mission of the United States Air Force is to fly, fight, and win in airspace and cyberspace. As an integral member of the joint team to ensure our Nation's freedom and security, guided by our strategic priorities and our emerging service core functions, our S&T program provides the balance necessary to ensure support for today's warfighter, while posturing for success against tomorrow's complex and uncertain future.

Chairwoman Sanchez, thank you again for the opportunity to present testimony. Thank you for your support of the Air Force S&T program.

Ms. SANCHEZ. Thank you, Dr. Walker.

[The prepared statement of Dr. Walker can be found in the Appendix on page 79.]

Ms. SANCHEZ. And now we will have Dr. Dugan.

Is that Regina? OK.

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

Dr. DUGAN. Good afternoon, Madam Chairwoman, Mr. Miller, and members of the subcommittee, Mr. Lemnios, distinguished colleagues. My name is Regina Dugan, and I am the Director of DARPA. I am proud to be here, and I am clear about the weight of my responsibility.

Over the 50 years of its existence, DARPA has achievements ranging from the Internet to stealth, from GPS [Global Positioning System] satellites to MEMS [Micro Electro-mechanical Systems] technology, from rockets to the M–16 rifle. We challenge existing perspectives, break glass, and make people excited and uncomfortable, sometimes with the same sentence. You might say that DARPA is the Nation's elite army of futuristic technogeeks, and this is our service to country.

The Agency's full testimony submitted in support of our budget request, details DARPA's contributions to the current fight, our ongoing programs, and novel initiatives that address some of the most complex problems of our time. When the country is at war and we can contribute, it is our duty to do so. Indeed, the Agency has been involved in support to active conflicts since the Vietnam War.

At any point in time, DARPA has technologies in all stages of development, from nascent idea to system ready for fielding. Recently, we accelerated fielding of systems to protect helicopters and ground vehicles in theater. Both capabilities promise to make it very dangerous to shoot at U.S. forces.

I believe that the breadth, urgency, and technical demand of these activities focus our work. The authenticity of such engagement inspires greater genius, and it cannot be created in the abstract. My recent trip to Afghanistan illustrated this principle and

reinforced our commitment. We must balance this investment with our responsibilities to the next generation of warfighters.

It was once considered inconceivable or at least ill-advised to fly an aircraft without a pilot on board. In the very near future, the United States Air Force will train more UAV [unmanned aerial vehicle] pilots than conventional pilots. And today we talk about blackening the sky with such systems. The UAV capabilities deployed on the battlefield today started at DARPA in 1984. And what originally seemed impossible has now become routine.

This progression characterizes many of DARPA's advances: first impossible, then improbable, eventually inevitable. And we take on new, seemingly impossible challenges each year, from hypersonic vehicle technology to tobacco plants used in vaccine production—which are related more than you might realize, because speed matters not only in global strike but also in our response to a biological attack; from nanoscale systems to quantum mechanical effects, which are related by an impact far disproportionate to scale, single sheets of carbon that may enable radar systems with 10 to 15 times greater range. That is a bit like having a really good right hook at the end of a 50-foot arm. Or quantum effects that may at long last unlock the secrets of the canine's keen sense of smell. DARPA's commitment to the care of our military men and women is one way that we honor their commitment to the Nation.

And we have ongoing programs devoted to stopping blood loss, diagnosing and treating traumatic brain injury, and assessing those at risk for suicide. I have spoken with amputees who were surprised by their own emotional response to receiving one of DARPA's advanced prosthetics and to feeling like a bilateral again. The realization that what they once thought was impossible no longer seems improbable but, rather, inevitable.

And our commitment extends to the health of our S&T workforce. We have a robust STEM program that extends from computer science to the use of microsatellites. And would you believe me if I told you that in the words of researcher Zoran Popovic, we could put games into science rather than putting science into games?

Believe. Because last year, Wired magazine reported a nail-biting play-by-play of the battle between a 43-year-old Paris-based marketing manager and a 13-year-old American who were in fierce competition to solve a protein-folding puzzle. And if you have ever tried to teach a student fractions, much less the fundamentals of protein folding, you can appreciate this amazing accomplishment.

We have other additional activities in work as we look forward to some of the challenges the Nation faces, from manufacturing to cyber. And whether you believe in a war metaphor or a law enforcement model for cyber, the goals of the response are common. At DARPA we are assembling some of the best and brightest to work this problem and committing significant resources. This set of programs and ideas is almost overwhelming in scope and potential impact, but they are not ours alone. Rather, they are the result of a 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 year we have redoubled our commitment to this ethic,

and we have aggressively engaged with three important constituencies: universities, industries, and the services.

Getting our business practices right is part of the job. It is said that ambition is a dream with a V–8 engine. And our full testimony highlights recent efforts to fine-tune the engine. Included are various efforts to empower our program managers and office directors and to fine-tune our processes.

What was once impossible, then improbable, and then inevitable, this progression characterizes DARPA's history, its present, and its future. The challenge serves as a timeless calling and a source of wonder for the organization, for those in it, and for those near it.

DARPA is the Nation's elite army of futuristic technogeeks. They are dreamers with V–8 engines, and this is their service to country. On behalf of these dreamers, I thank you, because DARPA's success is in part owed to you, to your support and confidence in our mission. Thank you.

Ms. SANCHEZ. I thank the Director.

[The prepared statement of Dr. Dugan can be found in the Appendix on page 96.]

Ms. SANCHEZ. And I see that Mr. Murphy of New York got scared away. But maybe Mr. Murphy of Pennsylvania would like to take my 5 minutes to ask his questions.

Mr. MURPHY OF PENNSYLVANIA. Thank you, Madam Chairwoman. And to the whole dais, thank you so much for your service to our country. And I appreciate it.

Dr. Walker, I will turn to you because my brother is in the Air Force. I am interested. What is Air Camp?

Dr. WALKER. Yes. Air Camp we are modeling—it is one of our STEM outreach programs for seventh, eighth, and ninth graders. And we are modeling it after Space Camp, which NASA has at Huntsville, Alabama. And what we are doing is we have a week-long week of activities in July where kids come in and we take them to the U.S. Air Force Museum, which is right there in Dayton, Ohio, which is a fabulous museum; take them to the Dayton Air Show, which is all the airplanes; we introduce them to the scientists and the engineers working at the lab; we show them what we are working on. We actually train them on a flight simulator and then take them up in an airplane and have them fly an airplane at the Aero Club there at Wright-Patt. So it is an outstanding—first time ever this summer, and we plan on having it every year, sponsored by Dayton businesses and the Air Force.

Mr. MURPHY OF PENNSYLVANIA. I am from the Eighth District of Pennsylvania, which is Bucks County and northeast Philadelphia. And in my district we have what is called ETC, Electronics Technical Corporation, sorry. So they did the simulators for Mission Space for Disney World, but also the Korean Air Force is a client, the U.S. Air Force is a client.

Do you see the simulators actually being more in the future, because we could save on gas and everything, part of the package that you all bring to the table? Because it is, frankly, it is usually—the technology now is pretty damn good training, and yet it saves the American taxpayer a lot of money.

Dr. WALKER. Certainly we are doing more and more pilot training with simulators. Obviously, all the remotely piloted vehicles,

you know, we train those guys on simulators. So simulators are a big part of where the Air Force is headed with training.

Mr. MURPHY OF PENNSYLVANIA. Thank you.

Dr. Lemnios, I wanted to touch base with you about—I note that DDR&E has a new program in cybersecurity. And I was hoping you could give me that line on what the goals are of that program. With cybersecurity, obviously, it is a major threat to our country. And if you could expand on that I would appreciate it.

Secretary LEMNIOS. Sure. Congressman Murphy, let me tell you how that came about and why it is in the program. It is of enormous interest to many people. I saw the testimony here on the 25th of February that had folks that addressed that similar topic. There is a professor from Cornell and two from the private sector.

About a year ago, the President's Cyber Policy Initiative was published. And right after that, when I came into office when we sort of stood up this S&T team, we looked at what would be the technical underpinnings to enable those cyber policy initiatives. The policy initiatives were sound, they made a lot of sense, but we were looking for what were the technical ideas that would enable us to work in that space.

And so we stood up a small 90-day study that included academia, that included industry, and certainly folks across the S&T community to really ask the question, What ideas do we have that would allow us to operate in the cyber domain as that policy review is sort of put in place? And that was really the foundation of the fiscal year 2011 request. It sort of allows us to move in the space of understanding how to operate effectively, attribution of attack, protection against attack, and it extends the technical side of what was started with the policy review that was published about a year ago.

Mr. MURPHY OF PENNSYLVANIA. Great.

Dr. Dugan, how about as far as DARPA, and what you are doing to meet our Nation's cyber challenges?

Dr. DUGAN. In 2010 and 2011, DARPA will invest over $300 million in cyber initiatives. And DARPA technologies are already prevalent in both commercial and military use. As an example, DARPA technology now protects all DOD network connections to the Internet against denial of service attacks. And the Agency is at the center of many new capability developments. Our track record of success is solid.

As I am sure you are aware, we also have the National Cyber Range, two prototypical efforts with 100 to 200 actual physical nodes and tenfold more virtual nodes as a means for providing a test bed for a whole variety of cyber initiatives.

Mr. MURPHY OF PENNSYLVANIA. Okay. Thank you.

Ms. SANCHEZ. Thank you, Mr. Murphy. And now we will go to Mr. Miller for his five minutes of questions.

Mr. MILLER. Thank you very much. And I will ask my—since you started with Mr. Murphy, if Mr. Conaway wants to take five minutes.

Mr. CONAWAY. Thank you. I appreciate that.

Panel, thank you for being here. Kind of at the 10,000-foot level, the chart we have got in our papers shows that the budget requests for this year are somewhat in line with the budget requests of last

year, but below the appropriations levels from this past year. Comments on that, Dr. Lemnios?

In particular, given the change in the Warfighter Act that put additional emphasis on prototyping, the drop in the request year over year and also over the appropriations in the 6.4 line item, which shows about an almost $2 billion reduction in the prototyping category. Help us to understand that relationship with the new law.

Secretary LEMNIOS. Mr. Conaway, let me point to two things. On the S&T side, the total S&T budget, the President's budget as submitted, as compared with the fiscal year 2010 PBR [President's Budget Request], is about the same. With regard to the 6.1, 6.2 and 6.3 initiatives, there was some shift to emphasize basic research and applied research in those areas. And those were really opportunistically driven concepts. We found ideas across the S&T community that would have a significant impact, particularly in cyber that we talked about, but in other areas, in forward base protection and other topics.

With regard to 6.4, the issue there was that we in fact have two new PEs, program elements, that address the Weapons System Acquisition Reform Act staffing and moving rapid prototyping concepts to field more rapidly. So those were intact.

There were some other activities that I would have to take a question for the record, to get back to you as to what the other adjustments were. But in general, sort of in broad terms, the focus of the S&T initiatives was to drive deeper investments in fundamental research. As we heard from Dr. Dugan, the connection with the university communities is absolutely critical to get new ideas to the field. And on the advanced prototyping side in the 6.4 efforts, we in fact have those in place.

Mr. CONAWAY. Thank you.

Admiral Carr, in your testimony you talked about the Navy's international S&T efforts. How do you pick those partners? How do you orchestrate the research so that we don't share a breakthrough with folks we don't want to share with, or those kinds of things? Can you kind of walk us through your thoughts there?

Admiral CARR. Yes, sir. Well, we are interested in regions of the world. We don't really pick partners just for point solutions. And the recent opening in Prague, for example, was to kind of help us with our window into Central and Eastern Europe. Prague has a rich academic tradition, by the way. And we have been doing some work with them, and the Air Force as well, on Autonomous Airborne Vehicle Sense and Avoid for several years now. The work we do is unclass, open source, so it is far removed from things where we would have to worry about classification, of course. And, really, we are there as much as to take advantage of the good research they are doing to avoid technological surprise.

So we have periodic briefings back at home on subjects of interest like meta materials, power and energy, unclassified basic research subjects, but just to watch what is going on in trends around the world.

Mr. CONAWAY. All right. I guess for all of you, how is the impact of the new law that was signed, I guess last year, on weapons acquisition in terms of how did that overlay with what you are doing?

Are there issues with that that we need to look at or be aware of that make the system less efficient, which is not the goal? We wanted it to be, obviously, more efficient and more value for the fighter. But what has been your experience with this so far? And I know it is early.

Secretary LEMNIOS. I can take a first crack at that because much of the Systems Engineering Initiative and the Developmental Test and Evaluation activity, both of those offices were staffed in DDR&E. They report to the Director of AT&L [Acquisition, Technology and Logistics]. But they are in our area because we wanted to couple those initiatives tightly to the S&T community. It is critically important. It is a workforce issue to make sure that the ideas that are going into the evaluation of system concepts indeed have the best benefit of seeing concepts that were starting to emerge from the research communities. And that is actually working very well. We are overlaid to a number of Department major defense programs doing technology readiness assessments for major defense programs that are underway. We are also doing manufacturing assessments of those. And we have coupled an entirely new cadre of folks to provide the technical underpinning and risk assessment.

And I think you will see shortly the first annual report to Congress on the Weapons System Acquisition Reform Act. It is due in a few days, and we are on track to submit that.

Mr. CONAWAY. Thank you, gentlemen, ma'am. I yield back.

Ms. SANCHEZ. The gentleman yields back his time. Mr. Smith, did you say you had a question?

Mr. SMITH. I have no questions.

Ms. SANCHEZ. Okay. Mr. Smith, the fact that you don't have any questions, I have one and then we will toss it back over to the other side. By the way, some of you are looking kind of bored out there.

Dr. Lemnios, I understand that the DDR&E has stood up a Rapid Fielding Directorate in order to address warfighter needs expeditiously. Would you please tell me how this directorate is going to be more responsive when, according to a recent report by the Defense Science Board, there are more than 20 programs already in the inventory that purport to rapidly transition technologies to the warfighter?

And also, what are the technologies that our warfighters have specifically requested? And have our S&T programs been able to successfully address those needs? And lastly, what are the outstanding warfighter's needs that have to be addressed?

Secretary LEMNIOS. Madam Chairwoman, that is a great question and it is the subject of most of my day, day in, day out. I have met with your staff quarterly. They understand the focus that we are putting on this. It is a personal push to make that happen.

I mentioned in my opening comments and certainly in my testimony the coordinates of innovation, speed, and agility. I will tell you, as you well know, as the committee well knows, those are the coordinates of any first-rate business. They are the coordinates of any innovative organization. We are slowly moving the Department in that direction. It is a challenge at all ends.

We started by meeting with each of the combatant commanders to understand what do they need in the field. I have met with the combatant commanders. The avenue to accept and to capture their needs is formalized in our Joint Urgent Operational Needs Statements. Those come in directly from the combatant commanders. We have a group that resources those directly. That is the highest priority that we put in place within my Department and within our focus. I will tell you, as well, that the Defense Science Board studies and the other studies that we have seen and we have tracked, in fact the Gansler report that you have referenced, also have addressed how do we cohere and how do we scale this enterprise? And we are looking at that. That story is not yet complete. It is largely driven by individuals that understand the intersection of the warfighter, technology, and what can be actually resourced through the Department and with Congress.

Each of these has been a mash-up. Each of these has been a hand-crafted concept that we have had to take through. We are doing that day in and day out. And we are working to try to harmonize and scale that to the right level.

I will give you two examples of concepts that have gone through and I think are starting to bear some significant results. Certainly the MRAP [Mine Resistant Ambush Protected vehicle] and the MRAP ATV [All Terrain Vehicle] is the icon case. That was a concept that started with a single letter from General Petraeus. It was resourced, it was put to the field. In fact, my principal deputy, Dr. Al Shaffer, Mr. Al Shaffer who is behind me, was a lead person in making that happen. From that letter from General Petraeus to the first vehicles that were in the field was less than six months. We are now on a ramp of producing these at a rate of about a thousand per month and delivering these to the theater. This is a remarkable concept.

It is a remarkable story of how we built a new capability that was never in anybody's plan when this first started, and yet the Department, Congress, the warfighter, came together to build a capability that is saving lives day in and day out. So it is critically important that we find ways to field those.

The Helicopter Survivability Task Force that we stood up last July came forward with a reprogramming action. Congress approved that action, and some of those concepts are now finding their way to the field. One of those concepts was the HALTT [Helicopter Alert and Threat Termination-Acoustic] anti-sniper that started at DARPA. It has been resourced. It is now being tested, and it will be deployed to the field later this year.

Each one of these is a hand-crafted sort of a concept that we have to hand-carry through the building. It is just the way it is. And we are trying to find a way to resource this at size.

Ms. SANCHEZ. Thank you. And now I will recognize Mr. Miller for five minutes.

Mr. MILLER. Thank you, ma'am. And I will yield my time to Colonel Kline.

Mr. KLINE. I thank the gentleman for yielding. Thank you, gentlemen and lady, for being here today, for your testimony. I apologize for not being here for the testimony. It is a crazy way this

place works. So you probably have covered some of the very issues that I would like to ask some questions about.

But I would like to get in questions, if I could, please, to the DDR&E, and then to Admiral Carr if time permits. I should let you know, sir, that everything I know I learned from members of your staff. So be ready.

Secretary LEMNIOS. Current or former?

Mr. KLINE. Yes. The answer to that is yes. I am looking at—this is a document prepared for us by HASC [the House Armed Services Committee], and it is listing science and technology priorities for 2011. It looks to be about ten or a dozen or so. It starts with medical S&T that DARPA is responsible for, expanded cyber protection, and it works its way down to STEM workforce, all.

So two questions. You perhaps don't have the same piece of paper I do. Are these priorities, are they lined up 1 through 11 or 12; or is this just a clump of priorities that you want 6.1, 6.2 to address?

Secretary LEMNIOS. So, Colonel Kline, I am not sure I have that particular piece of paper, but I think I know——

Mr. KLINE. The gist of it is medical S&T, the highest priority, and we are working our way down to STEM. Or is it more amorphous than that?

Secretary LEMNIOS. No, there are a core group of concepts that have come through numerous studies. And when you step back and look at these, whether they come from the Defense Science Board, whether they come from the National Academies, whether they come from internal studies, and you step back at 30,000 feet, there is a handful of topics that always find their way to the top of the list.

Cyber is absolutely on that. And the barrier there was finding the right technical ideas to go pursue. So our study that we launched last year answered that question. And that was the subject of the PBR 2011 submittal. We have done that in other targeted areas.

Electronic warfare is another one where we launched a targeted study to try to understand what could we do in this field that would have significant impact for the Department 5, 10, 15 years from now, where the adversary is also in that field on a commercial time scale?

DARPA has launched a whole set of programs five years ago that will open new frontiers in biomedical engineering and new frontiers in prosthetics.

Mr. KLINE. All right. Let me interrupt because I am going to run out of time. I get the idea that these things have risen to the top. And I guess my question was: Does everybody agree that medical S&T is first, followed by cyber, or are these taken together as a group, the areas you are going to focus S&T?

Secretary LEMNIOS. Those, taken as a group, are the sort of 80 percent region of what the focus is. We want to find outliers that will have significant impact.

Mr. KLINE. Sure.

Secretary LEMNIOS. And that is a subject as well.

Mr. KLINE. Right. Hopefully that would happen in some basic research.

Let me ask you about STEM. Obviously, there are a lot of people talking about STEM and educating Americans across the board. But you have gone so far, as I understand it, to stand up a new office. Tell me about that office. I, having lived and worked inside the DDR&E's spaces, that is pretty amazing. It is hard enough without standing up a new office and new goals and new purposes and new people. Tell me about that.

Secretary LEMNIOS. So what we have done there is stand up a board of directors, not a new office, but an organization that allows us to take—first of all, bring to bear those across the Department that have concepts in STEM across the services and DARPA and the balance of the DOD enterprise, and bring together the best practices to try to understand where we could make improvements in the overall STEM posture. So this is really a board of directors-type model.

We have then gone back, we are going back now to try to understand what are those critical technologies—so there are really two parts to this. One is the overall STEM initiative, and that is much larger than DDR&E. In fact, that is a national issue. But then there is the DOD piece that is identifying the critical technologies where we have to have core competencies, systems engineering being one, and we need to make sure that in fact we have those courses, the students that are tracking those courses that are finding their way into DOD service.

So in the area of systems engineering we are standing up a set of capstone courses with a number of universities this year to try this experiment. And the experiment is let's find the targeted areas where the DOD really needs core capabilities, let's identify the schools that could really resource that through open competition, and address a course structure and a set of courses that allow the students to matriculate through those avenues.

Mr. KLINE. Okay. I know I am over my time, but I just want to make sure I understand you haven't set up a new office with a new SES [Senior Executive Service] 3, 4, 5-something running it, and a military assistant and some other staff inside the DDR&E.

Secretary LEMNIOS. That is staffed by a program manager.

Mr. KLINE. Okay.

Secretary LEMNIOS. And she is pulling together the best practices across the Department to try to understand where we could have significant impact.

Mr. KLINE. All right. I see my time has expired. I yield back. I am sorry.

Ms. SANCHEZ. You are just stealing time from Mr. Miller. Mr. Miller.

Mr. MILLER. Thank you very much. Kind of following on what I think Mr. Kline was just talking about. And Admiral, I think you talked about the landscape changing in S&T. And I just would like to hear from each of you in regards to retaining the best possible people, recruiting and retaining the best possible folks that are out there. Are we doing enough? If not, what can we do better? Anybody that wants to start. Admiral?

Admiral CARR. I will start. I think we are recruiting and retaining wonderful people. It is not just a Navy or a military issue. I think the country needs to do more. The statistics show that we are

graduating more people with technical and advanced degrees, but we are not keeping up with demand. We are diverging there. And last year for the first time in this country, we awarded more advanced degrees to non-U.S. citizens than to U.S. citizens. So we need to think about how we are going to create a climate where we encourage more young people to pursue careers in science, technology, engineering, and math.

Of the 2.5 million students that graduate from high school, about 2 million go on to college; half of them consider technical education; fewer than half of them, 480,000, actually graduate; and about 186,000 go on to pursue technical degrees.

Those numbers just aren't enough. It is not just a Navy issue, but we all want a piece of it, and we all certainly selfishly want to make sure that the base is wide enough so we can draw from it. We contribute to it about $40 million a year from the Navy to STEM outreach and education in the form of grants, scholarships, competitions, and other support.

And I will leave some time for others to answer.

Dr. KILLION. I will take on a bit of that. Another part I think you were mentioning is about getting folks into our labs and centers. What has been very gratifying over the last—I have been here a while. I have come here more times than anybody else at the table, so I can say this. As Mr. McClees knows, I have been in this business working with the Army for quite some time. It has been great over the last decade. Not necessarily for the best reasons, because we are at war; but because we are at war, our labs and centers have been able to attract and support growing of the workforce, to really bring in new young people with good ideas that are interested in contributing to what can be done for this Nation. They are excited about the kind of work that gets done. And we give them interesting problems to work upon. That is the key part.

Part of the challenge is being able to hire them quickly. And the Congress has been very magnanimous in giving us additional authorities that have allowed us to do that. And we need to exploit those to the greatest extent possible and show to you that we need to have even more authority in that domain so that we can hire people quickly. Because if you have to say, Yeah, we want you, but come back in six months after we have gone through our whole paperwork process, that is not going to work and we will not be competitive. So to be competitive we have to have that direct-hire authority.

Another piece of it is having the facilities and environment in which you can actually do the cutting-edge research that needs to be done. Some of the authorities that we have gotten in minor construction have really helped us. We are working with DDR&E on how we develop a strategy for more robust facilitization of our laboratories going forward, because we have to stay at the state of the art if we are going to attract young people who are interested in doing work in science, math, and engineering with our Department and in our laboratories and centers.

Dr. DUGAN. I would like to add, to give you some insight on the output that we have already seen from some of our STEM activities. So we have a program entitled Inspire, which utilizes microsatellites inside the Space Station as a platform for student-led ex-

periments. That program has graduated more than 80 students from undergraduates to Ph.D.s, with already a noticeable impact, as we have seen graduates from the program among the top technical experts across all the major space industry primes.

And you heard me mention something about a very novel program that we have entitled Fold It. It was developed by a researcher named Zoran Popovic. And Fold It takes a new approach to inspiring and capturing the imagination of many young people, and actually those who haven't been previously associated with science. The protein-folding puzzles, these puzzles for science in Fold It, have really elicited a very interesting phenomenon. Since the launch of Fold It in May of 2008, over 120,000 people have participated in protein-folding experiments, and an average of 200 new users sign on a day. Of the 20 top players, only one to two have had experience in biochemistry. So it is a very interesting example, I think, of the importance of innovative strategies to not only train, but to capture the imagination and inspire wonder in science and engineering as it pertains to the Department's needs and the Nation's needs.

Ms. SANCHEZ. Anybody else out there want to add to that question?

Secretary LEMNIOS. Let me just add one more comment. The example of the capstone course that I mentioned I think is a good example of how we are trying to change the equation, how we are really trying to drive the inspiration of kids and young engineers into the fields that we have all enjoyed.

This is also very personal for me because in fact my wife is very much involved in STEM, trying to inspire young women to move into science and engineering. It is something that we talk about at the dinner table. It is a good part of our life.

But the key part of this, it seems to me Dr. Killion mentioned the key pieces: having the right facilities, having the right challenge problem, and building the mentorship day to day that inspires a student to move into a field and have some traction that they in fact can achieve and they can contribute.

The capstone courses that we are putting in place, we are starting with the service academies, we are moving to a few universities. Each of those couple graduate students, and perhaps undergraduate students, with a DOD user, with somebody in uniform that understands a challenge problem. It might be a UAV control problem. It might be an undersea autonomous vehicle problem. And that user will work with the students hand in hand as a mentorship to try to affect a capability that might eventually transition to the user side of the equation.

Working as a mentor over a period of time is really what is needed. And we are trying to build those channels. And they are handcrafted, but those are the channels we are trying to build with a few universities this year and then scaling that to something much larger next year.

Dr. DUGAN. I would like to add just one more thing. Oh, Tom.

Ms. SANCHEZ. We have a bit of time. They have just called votes, so we might have another five or six minutes. So I think we can get both of your responses in.

Dr. DUGAN. I would just like to add that I think it is important we recognize that the talent pool, the mind share is global now. And we have seen evidence of this in our engagement with universities as we have sought to protect the basic elements of fundamental research within the university setting as well as national security.

And as an example, we have a young fellowship program. It is designed to bring young, very bright professors to Department problems. And previously, that award was granted only to those who could secure a security clearance, which became a surrogate for U.S. citizenship. And what we recognized in that program was that many of the universities were stepping away, or they were reluctant to participate because they had recognized on their own campuses that the mind share is global.

For many of the top universities, the sun never sets on their campuses. They have campuses all across the world. And so we relieved that restriction, with full awareness and protection of national security interests, so that on balance we could bring to the table some of the best minds present in the country, whether or not they are U.S. citizens, to participate in fundamental research. And I think we have to develop strategies for understanding and capitalizing on the nature of this global talent pool writ large.

Dr. KILLION. Okay, so my story is a little less, let's say, formal than that, but it is refreshing, because I went to speak at my granddaughter's third-grade science class. And I pulled together several science classes, and I brought in some robots, and let them see the robots, they got to see the video from the robots to do this. It was the most intense hour-and-a-half session I have ever had in my entire career in terms of you can't imagine the arms in the air asking questions. Had to avoid the questions about do you put guns on these robots. But the key was they are excited about science and engineering and technology at that age.

Our challenge is keeping them excited, giving them the kinds of problems that Regina is talking about, so it keeps them interested and makes them realize they are able to do this and it is important. And providing that environment when they come into our laboratories, where they will stay excited and stay with us, because we need their expertise and their ideas. Third graders are great, but we do need those graduate students, too.

Ms. SANCHEZ. Well you know, it is an interesting thing, because I sit on another committee called the Joint Economic Committee. And we had at that time Chairman Greenspan of the Federal Reserve. And we were talking about all this international stuff and the Chinese currency, what you read in the papers, et cetera. And at one point he said to us the problem is education. He said, I don't know what happens, but in third grade our kids test at the top of any level and by the eighth grade they are 43rd in the world as far as what is going on.

So, as I heard some of your comments about we need to keep them interested and everything, I was thinking to myself we need to keep them interested between the third and the eighth grade to get them there.

And personally, being a Hispanic, when I take a look at the fact that 50 percent of Latina students in our Nation fail to complete

the 12th grade—you know, most people see the high school dropout rate and they see 20 or 25 percent, but the reality is it is at 50 percent. If you are in the 11th grade, go and get a job at McDonald's, you are not considered a dropout if you leave school to go and get a job at McDonald's.

So we are looking, and I realize what you said, Dr. Dugan, about opening it up to other worlds or other nations. But the reality is we are still looking at what do we need to do to our workforce, home grown here in the United States, to get them to do these science and technology programs.

And I guess I just will relate back to what you said, Dr. Killion. I had the opportunity after 12 years of being in the Congress to finally go to the South Pole. I think the Congress people get one trip every two years through the Science Committee. And of course, the people on the Science Committee get to sign up first. And finally after 12 years—I don't sit on the Science Committee—I got an open slot and I got to go to the South Pole, which was really one of the most amazing trips that I have ever made. To see the scientific research being done on that continent and to understand the possibilities—it was really an amazing thing to meet with my graduate students from Stanford and from UCLA and people from Boston and others just bringing their grad students to do the type of research that we collect there. It was just the most amazing thing.

But there happened to be this penguin colony there also. And there were these video cams set up out there where it was picking up 24 hours a day what this penguin colony was doing on the ice, how they were living, what they were doing, et cetera. And they told me, "Well, the scientists said you can go in there because this is on a cam; but we do it so that you can go to the Web site, and teachers in the third grade can teach their students about the scientific knowledge about what is going on with the penguin."

So I came back to my district and I said to my teachers, you know, there is this great program that we are funding, actually, where we have this penguin colony, and you should really tap into it and figure out how to use it and everything. And I went back maybe about six months later to one of the classes where they were doing this, where they had followed the penguins every single day. And these kids were so excited about science.

So you are right. We have to keep them excited, because it can't just be in the third grade. It has to be all the way, so we can get them through geometry and trig and algebra II and calculus and everything else, to get them to be our engineers of the future.

I thought that was one of the most worthwhile trips I took, and actually was able to bring something back to kids in my district.

Admiral, before I put down the gavel and we go and take our votes.

Admiral CARR. I would just add that that sweet spot of inspiration is right there in about junior high school. Much beyond that, kids have begun to make up their mind. So I know we all fund across from K through 12, all the way up to graduate school, but it is a very important spot right there in junior high. We need to aim there.

Ms. SANCHEZ. Thank you.

To the members of my committee, anybody have another comment or anything?

If that is it, we will adjourn and we will go to votes. Thank you all. The committee is now adjourned.

[Whereupon, at 4:14 p.m., the subcommittee was adjourned.]

A P P E N D I X

March 23, 2010

PREPARED STATEMENTS SUBMITTED FOR THE RECORD

MARCH 23, 2010

The Honorable Loretta Sanchez
Committee on Armed Services
Subcommittee on Terrorism and Unconventional Threats and Capabilities
"FY 2011 National Defense Authorization Budget Request – Department of Defense Science and Technology (S&T) Priorities"
March 23, 2010

Opening Statement

Good Afternoon,

I would like to welcome you all and thank you for joining us today to receive testimony on the Department of Defense's Sciences and Technology (S&T) policies and FY11 budget request for S&T programs within the Office of the Secretary of Defense.

The Department's S&T program supports defense requirements for superior future warfighting capabilities by developing needed technology enhancements, as well as rapidly transitioning critical technologies to our warfighter, interagency and international partners, and the industrial base.

Over the last couple of years, Secretary Gates has challenged the old business and operational paradigm of the Department of Defense developed during the Cold War.

In a strategic environment in which the US will continue to prosecute persistent hybrid threats while simultaneously dealing with larger near-peer competitors as well as the myriad of unconventional and irregular threats, DoD's S&T enterprise must be responsive and robust enough to hedge against uncertainty.

The S&T investments should be flexible and balanced to address emerging challenges such as cyber warfare, force protection, and energy, as well as breakthroughs in long-established areas like medical

technology, platform survivability and sustainability, ISR, and environmental remediation.

Not only must these investments maintain our technological superiority, but it must find innovate ways to rapidly field these technologies at affordable prices.

The DoD laboratory system and scientific workforce has traditionally kept the US at the forefront of technological advances.

However, over the last 5 years, experts have argued that the United States' dominance in science and technology has begun to erode.

DoD senior officials have testified that the Department's science and engineering workforce has experienced an attrition of more than 13,000 personnel over the last 10 years, while the demands for that same workforce is projected to increase by over 10% in the next five years.

I believe a solid Science and Technology base is not only a prerequisite for maintaining a strong military, but it is an absolute necessity for this country's national security. Maintaining that superiority means more than simply funding the right research- it means investing in the laboratory infrastructure and technical workforce that provides the foundation for all of those advances.

Through this hearing, I hope to gain a better understanding of what our witnesses see as our top Science and Technology priorities, and hear your views about how this subcommittee can meet the challenges of sustaining a top-of-the-line Science and Technology Department for DoD.

Today, we have five witnesses before us who represent key leaders in the Department of Defense who are responsible for discovering, developing, engineering, and fielding innovative technologies that give our warfighter's the capability edge.

First, we have:

The **Honorable Zachary Lemnios,** who is the Director of Defense Research and Engineering for the Department of Defense,

Along with **Dr. Thomas Killion,** Deputy Assistant Secretary of the Army for Research and Technology,

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

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 (DARPA).

Once again I would like to thank all of our witnesses for being here today and I look forward to hearing your testimonies.

I will now yield to the Ranking Member from Florida, Mr. Miller for his opening statement. Thank you

Mr. Miller Opening Statement for Hearing on Department of Defense Science and Technology Investments

March 23, 2010

Washington, D.C.—House Armed Services Subcommittee on Terrorism, Unconventional Threats and Capabilities Ranking Member Jeff Miller (R-Florida) today released the following prepared remarks for the subcommittee's hearing on the Department of Defense Fiscal Year 2010 budget request for science and technology:

"Last May, this subcommittee held a hearing on the Department of Defense's Science and Technology investments. At that time, I was among many others who expressed concern about Secretary Gates' decision to reshape the Department's investment priorities because we had only been provided Fiscal Year 2010 budget figures and the 2010 Quadrennial Defense Review (QDR) had yet to be complete.

"This year, we have both the 2010 QDR and a full Fiscal Year Defense Plan (FYDP) to accompany the Fiscal Year 2011 budget request, but I must say I remain concerned with the health of the Department's science and technology programs. As expected, Secretary Gates has maintained the Department's focus on 6.1 and 6.2 investments. These basic and applied research areas are the building blocks of leap-ahead technologies and capabilities that our military will use more than a decade down the road, so they are certainly an important part of our overall military strategy.

"Of course, the Department must find an appropriate balance between the immediate needs of the warfighter and the research and development needed to keep our military ahead, technologically, of our competitors. So while I am encouraged that basic research investments remain well funded, I am gravely concerned that the medium-term investments – primarily in advanced technology development – are being overlooked.

"We face many challenges in today's world, and we cannot imagine away potential threats that may emerge in the next ten years. So while we must address the immediate needs of our troops engaged in Iraq and Afghanistan, I have to ask whether we are positioning ourselves well for the future by decreasing the mid-term research and development investments to keep basic and applied research strong. With this in mind, I would be very interested in hearing from our witnesses what risks the Department may be assuming by taking this approach.

"Further, given the difficulty in balancing investments with a limited budget and two on-going conflicts, I am concerned about whether further budget pressures will emerge as the Department moves forward with Acquisition Reform. Additional prototyping and development is now required earlier in the acquisition cycle to try to identify and correct technical failings that have created program delays and significant cost overruns in many previous programs. While I applaud such measures so that we can improve the likelihood of success, I understand that your

research and development budgets have not been adjusted to appropriately reflect the potential costs of this additional testing and development.

"So, the gap that potentially exists in our advanced technology development investments may be exacerbated if already limited funds must be diverted to meet new requirements for the acquisition process. I would certainly like to hear from each of you about your view on this under-recognized, but potentially critical, issue.

"While I have raised two of my concerns, I must recognize that we have before us some of the most dedicated, professional, and smart people in the Department of Defense. You are working on keeping our forces equipped with the very best, and prepared for the very worst. You have done an outstanding job, and our interest and our responsibility is to ensure that you have what you need to give the warfighter the capability required for success on the battlefield."

NOT FOR PUBLICATION UNTIL RELEASED BY THE SUBCOMMITTEE

Statement Testimony of

The Honorable Zachary J. Lemnios
Director, Defense Research and Engineering

Before the United States House of Representatives
Committee on Armed Services
Subcommittee on Terrorism, Unconventional Threats and Capabilities

March 23, 2010

NOT FOR PUBLICATION UNTIL RELEASED BY THE SUBCOMMITTEE

Introduction

Good afternoon Madam Chairwoman, Ranking Member Miller. I am pleased to be here today on behalf of the dedicated men and women working in the Department of Defense, Research and Engineering (DDR&E) enterprise who discover, develop, engineer, and field the critical technologies for our Service Members, and civilians deployed in the defense of our Nation. 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. Tom Killion from the Army, Rear Admiral Nevin Carr from the Navy, Dr. Steve 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 success of our forces to meet today's challenges and to prepare for the future.

I am here today to describe the FY 2011 President's Budget Request (PBR-11) for science and technology, to show how prior investments have maintained our technological edge and to show how the FY 2011 investment will continue to provide critical capabilities for our Nation's security.

Innovation, Speed, and Agility

We are in a period of 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 US military's dominant operational capabilities were largely due to the continued development and delivery of superior technology by the defense research and engineering enterprise. This enterprise has successfully worked in the past with the university research community and the defense industrial base to develop the underpinning technologies for stealth aircraft, precision weapons, reconnaissance and positioning satellites, lasers, advanced lightweight materials, and the internet.

While effective against linear threats, this long-term development model is not well-suited for the new security environment which requires adaptation, innovation, and delivery on the timeline of weeks and months. Dominant operational capabilities in the future will be underpinned by weapon systems that can rapidly adapt to changing environrments. To meet the demands of near-term and future system challenges, the

[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). Basically both S&T and R&E are activities that occur before initiation of formal acquisition programs.

Department is opening new avenues of innovation and fundamentally new research and engineering approaches that result in a steady flow of credible technology options. We are working to engage a deeper pool of private sector talent and are encouraging a new generation of young scientists and engineers to pursue career paths in support of our Nation's security.

Renewed Role of S&T

As I look to the challenges facing us I see a renewed role and increased importance for S&T in support of our Nation's defense. This has been clear from my very first day in office. This new focus was informed by the broader range of challenges outlined in the Secretary of Defense (SecDef) April 6, 2009 Defense Budget Recommendation Statement[2] and further highlighted by the numerous briefings I received prior to my Senate confirmation hearing.

The SecDef has been clear about his three principal goals: reaffirm our commitment to take care of the all-volunteer force; rebalance the Department's programs to institutionalize and enhance our capabilities to fight the wars we are in today and the scenarios we are most likely to face in the years ahead, while at the same time providing a hedge against other risks and contingencies; and reform how and what we buy, meaning a fundamental overhaul of our approach to procurement, acquisition, and contracting. To meet the SecDef's goals, the DDR&E enterprise is pursuing solutions across the entire spectrum, from technology discovery to delivery of capabilities, and most importantly we are striving every day to rapidly deliver these capabilities to our men and women in uniform.

I view outreach as an important element of our strategy to implement the SecDef's goals. During my first months as DDR&E, I made it a priority to visit all of the Combatant Commanders (COCOMs) to understand their near-term priorities and their future needs. I heard some common themes from our discussions and the need for immediate solutions. Each COCOM asked for the 80% solution in the field today, rather than 100% solution years from now. The Commanders asked for my help in finding ways to innovate in the field, and we did this by coupling our S&T workforce with the users in the field to provide immediate feedback to our rapid prototyping and formal acquisition programs. In fact, there are now over 70 embedded science and technology advisors that provide direct feedback and assessment of ongoing development programs. These are our technology scouts and transition agents in the field.

During my visit to Special Operations Command (SOCOM) last fall, I was fortunate to meet Senior Chief Petty Officer Chris Beck who works with the SOCOM S&T advisor. Chris is a remarkable individual and has spent most of his 20 year of service as a Navy SEAL operator forward deployed, most recently in Afghanistan. He

[2] U.S. Department of Defense, *Defense Budget Recommendation Statement as Delivered by Secretary of Defense Robert M. Gates, (Arlington, VA)*, http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1341 (Apr. 6, 2009).

brings a wealth of knowledge to both the S&T and the acquisition efforts. Chris bridges the gap between the capability providers and the operators and ensures systems are relevant to the current fight and operate properly in the most challenging environments. One of SOCOM s most interesting concepts is a deployed rapid prototyping capability, which allows design, fabrication, modification, and testing of components and systems in the field. The first capability in terms of personnel and equipment is currently in Afghanistan, and in April, the first Mobile Technology Complex will deploy. This will enable operators to repair and upgrade deployed systems in hours and days, vice weeks and months. The importance of this connection between the warfighters and the S&T enterprise cannot be understated; in fact, I intend to grow and strengthen these connections.

An Integrated S&T Enterprise

The DDR&E enterprise encompasses a remarkable pool of talent and resources. Our footprint includes 67 DoD laboratories dispersed across 22 states with a total workforce of 61,400 employees; 35,400 of whom are degreed scientists and engineers, who publish thousands of reports and peer-reviewed technical papers. We operate 10 Federally Funded Resarch 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 system 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 Joint Reserve Unit (JRU) within DDR&E. In fact, in FY 2009, the Department issued approximately 2000 SBIR Phase 1 awards (as a result of 12,000 proposals), and approximately 900 Phase 2 awards and engaged in almost 3,000 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. As part of this engagement, the Joint Reserve Unit (JRU) provides DDR&E with a unique surge capability and talent resource that extends the Department's reach into the public and private sector. The JRU's team of joint service reserve personnel create a "knowledge network," facilitating sharing and capture of emerging, innovative, and disruptive technologies, in order to maintain the U.S. military's preeminent capability advantage. With strong ties into the science, technology, engineering, venture capital and finance commercial sector, the JRU provides us with fresh perspectives through dynamic and innovative thinking while augmenting our resources for emergent national security issues.

Lastly, the Department continues to have deep connections with our Nation's universities and colleges. Across the full S&T portfolio, we support over 5,000 undergraduate and graduate students through our research programs, Science, Mathematics And Research for Transformation (SMART) scholarship-for-service program and our National Defense Science and Engineering Graduates (NDSEG) graduate fellowship program. The Department of Defense, funds about 11 percent of all full time science and engineering graduate students supported by the Federal government, and does so in all 50 states.

We are in a unique position to leverage this "Research Triple"[3] of industry, academia and the DoD S&T enterprise engaged to advance new technical ideas in response to an emerging set of National security challenges. This successful model was demonstrated by the SEMATECH, the Semiconductor Research Corporation and the subject of much analysis validating the business and transition leverage.[4] It draws upon the core basic and applied research methodologies of academia and the experience and successes of the commercial marketplace to rapidly transition innovative research results to both commercial and military applications use.

Coordination among our S&T organizations is strong and vibrant. In January of this year, I hosted a 3-day Reliance 21 Science and Technology Strategic Overview meeting along with the S&T executives from the Services and Agencies to synchronize efforts across the Department's $12.0 billion S&T investment. The objective of Reliance 21 is to integrate ideas and execution paths for a broad range of technology concepts across the Department. This meeting included representatives from DARPA, the Services, the Defense Threat Reduction Agency (DTRA), the Joint IED Defeat Organization (JIEDDO), the Missile Defense Agency (MDA) and Nuclear & Chemical & Biological Defense Programs.

DDR&E Fast-Ramp Initiatives

Innovation, speed, and agility are the new hallmark characteristics of the DDR&E enterprise. For example, I launched a set of short-deadline, fast-ramp initiatives to identify solutions to the challenges I learned during my initial meetings with the COCOMs and subsequent discussions with the DoD Joint Staff. We examined cyber; computer science; electronic warfare; tagging, tracking and locating; helicopter survivability; applied advanced mathematics; development of a rapid capability toolbox; and deployable force protection. Each study was tasked to develop a thorough understanding of the technical challenge and the emerging threats, to recommend mitigating capability concepts to mitigate the challenge and to identify and also devise a credible technology transition strategy. We captured ideas from across the S&T enterprise, industry and academia. The reports were delivered in late summer and early

[3] Zachary J. Lemnios and Alan Shaffer. 2009. *The Critical Role of Science and Technology for National Defense.* Computing Research News, Vol. 21/No. 5: http://archive.cra.org/CRN/articles/nov09/defensetech.html

[4] William B. Bonvillian, "Power Play, The DARPA Model and U.S. Energy Policy," *The American Interest* II(2):39-48, 2006

fall and were used to confirm ongoing efforts and prioritize new S&T initiatives, which were included in the PBR-11.

Guided by this approach, PBR-11 is structured as a portfolio of technologies, capabilities and engineering efforts to rapidly identify, develop and field capabilities; to streamline the acquisition process; to understand the current and future landscape; and to place a premium on innovation throughout. During the PBR-11 budgeting process, the DDR&E staff was actively engaged with the Office of the Undersecretary of Defense for Policy while creating the 2010 Quadrennial Defense Review (QDR)[5]. The QDR released in February by Secretary Gates has many S&T threads which provide further reinforcement for the critical efforts of our entire R&E enterprise.

Guidance for S&T Activities

The QDR outlined a series of recommendations aimed at rebalancing America's Armed Forces to better enable success in missions critical to protecting and advancing the Nation's interests. The QDR also recognized the need to strengthen our technology and industrial bases to maintain our technological edge in a dynamic, diverse and evolving threat environment. The 6 mission areas were identified as follows:

- 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
- Operate effectively in cyberspace

In August 2009, the Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB) jointly released priorities to be supported through the FY 2011 Budget.[6] This guidance was instrumental in development of the FY 2011 submission and reflected in an increase of 9.5% (or just over $200 million) in basic science funding. This additional funding has been dispersed to the Services and agencies to support Administration priorities within the fundamental sciences. It will address our hardest problems with new, transformative capabilities that come from the new tools of basic research. Examples of increased efforts in basic research include: advanced nanoscale manufacturing; ultra-short lasers to explore the new physics and chemistry phenomena far from equilibrium; computational cognitive science; cyber security; quantum information science; and advanced materials for counter-improvised explosive devise applications.

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[5] U.S. Department of Defense, *2010 Quadrennial Defense Review, 2010.* http://www.defense.gov/QDR/images/QDR_as_of_12Feb10_1000.pdf

[6] The White House, Washington DC, August 4, 2009 M-09-27 Memorandum for the Heads of the Executive Departments and Agencies from Peter R. Orszag, Director, Office of Management and Budget and John P. Holdren, Director, Office of Science and Technology Policy

DDR&E Imperatives

To focus the organization in support of the immediate and future needs of the Department of Defense, I introduced 4 Imperatives:

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

Accelerate Delivery of Technical Capabilities to Win the Current Fight

COCOMs want results today. They want the S&T enterprise to deliver an 80 percent solution today versus a 100 percent solution two or more years from now. While typical technology transitions have been counted in years and decades, militarily-useful solutions are needed in weeks and months. To satisfy priority operational needs in a timely manner, we are working to deliver capabilities on par with commercial cycle times and costs. The first DDR&E Imperative specifically addresses this need and maintains the S&T focus on the innovative fielding of capabilities. Examples of current and future activities in support of this Imperative are:

Joint Concept Technology Demonstrations (JCTDs)

The role of the JCTD Office is to speed the discovery, development, and delivery of technology and concepts for sustained joint military capabilities or, more simply put, to operationalize innovation faster than ever. Each JCTD project exploits mature and maturing technologies and introduces new operational concepts to solve important military problems and facilitates transition of these new capabilities from the developers to the users.

Earlier this year the JCTD process was restructured based on inputs from the Joint Staff, the Vice Chairman of the Joint Chiefs of Staff, the COCOMs, the Undersecretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)), and congressional staffers to shorten the time from idea to first proof of concept to 12 months. The new process works on quarterly cycles (3 month) for new starts, and for review of ongoing projects. These quarterly decision and review boards are chaired by the DDR&E and co-chaired by the Deputy, J8 from the Joint Staff. Every new start will have a clearly identified one-year deliverable to assess progress and to provide the Joint Requirements Oversight Council (JROC) a demonstrated capability prior to requirement validation. Our legacy process averaged 3 to 4 years per program, this accelerated process is designed to have more demonstrations earlier with a clearly-defined down select process at the one-year point.

The coupling of the JCTD process with the Joint Experimentation (JE) effort was initiated this year. The JE program validates the highest priority Warfighter challenges from the COCOMs and develops operationally relevant experimentation opportunities to

assess current and future tactics, techniques and procedures. When able, we are using these experimentation venues to test our prototype JCTD systems with actual service members operating in threat-representative scenarios. The synergy between both these programs will optimize the doctrine and capabilities delivered to our warfighters.

Helicopter Survivability Task Force (HSTF)

As I mentioned earlier, one of my first initiatives upon arrival, was to launch a set of quick-turn studies. The HSTF was one such study, with the objective of identifying, demonstrating and integrating capabilities to mitigate the threat of small arms fires and safety risks to helicopters operating in Iraq and Afghanistan. Of these candidate programs, the Helicopter Alert and Threat Termination - Acoustic program (HALTT-A), was in early stage development by DARPA and is more fully discussed in the testimony submitted by DARPA. DDR&E assisted in the resourcing of the follow-on testing, and airworthiness certification of an operationally-representative system configuration for the 16 acoustic sensors, associated computers and pilot displays. This fast track integration and testing will shorten the delivery timeline by years.

Joint Rapid Acquisition Cell

The Joint Rapid Acquisition Cell (JRAC) tracks, coordinates and addresses Joint Urgent Operational Needs (JUONS). JUONS are identified by COCOMs and are usually capability gaps that result in casualties or potential loss of life. The JRAC has the ability to draw on the capabilities developed elsewhere within the Department and employs Rapid Acquisition Authority to obtain the capabilities identified by the Warfighter.

A good example of the JRAC's ability to move quickly through the acquisition process is the Persistent Ground Surveillance System (PGSS). The PGSS was an offshoot of a JCTD project, which took less than 60 days to get started; it provides a low-cost alternative for an integrated, intelligence surveillance reconnaissance (ISR) system. PGSS provides persistent overwatch, threat detection, and communications relay for our forward operating bases. The initiative directly supports coalition forces in Afghanistan, and accelerated from start-up to initial deployment in 6 months, with strong Army partnership and Army sustainment strategy.

Rapid Reaction Technology Office

The Rapid Reaction Technology Office (RRTO) has conducted a number of projects to develop tools, models and assessments to support the policy, strategy, and operational strategic communications community within DoD and the interagency. RRTO fosters research and development of special capabilities, and other non-kinetic capabilities from a "whole-of-government" perspective, by forming partnerships with Office of the Undersecretary of Defense (Policy), the State Department, Office of the Undersecrtary of Defense (Intelligence), the Departments of Homeland Security and Justice, and other non-governmental organizations such as the US Institute for Peace. Two projects are highlighted below:

The Pakistan and Afghanistan Rich Contextual Understanding (PAKAF RCU) Strategic Multi-layer Assessment: The purpose of the PAKAF RCU project is to provide the International Security Assistance Force (ISAF) Commander with a rich contextual understanding of multiple dynamic environments, situations, locations, messages, and people in the PAKAF area. General McChrystal specifically asked for support from PAKAF RCU late last year. The overall project is limited in scope to 16 districts in three provinces in Afghanistan (Kunduz, Paktika and Helmand) and 10 districts in Pakistan. It consists of six interrelated components: 1) development and population of classified and unclassified, annotated and searchable data libraries, 2) "all-district" data generation and multi-method assessment efforts, 3) a "deep dive" on Helmand province, 4) response to "40 Questions" directed by Major General Flynn (ISAF), 5) production of "rich contextual" materials, and 6) development of an RCU-Vis software application containing easily accessible and searchable information on the sixteen districts in Afghanistan and Pakistan. The project depends on a variety of methods for data collection, including polling, crowd sourcing, audience analysis and agent-based modeling.

The Afghanistan Virtual Science Library (AVSL): The project's goal is to have workers in the Afghanistan civilian population gain the skills and resources needed to support stability and security operations, preserve existing intellectual capital, encourage new professional relationships, and support a traditional source of moderate leadership in Afghanistan -- engineers and scientists. The U.S. Civilian Research and Development Foundation (CRDF) is managing the pilot program to provide students and researchers at the University of Kabul with access to up-to-date publications and knowledge resources in a cost-effective and accessible form. This will establish a baseline for implementation of a nationwide virtual science libary adapted for Afghanistan's needs.

Prepare for an Uncertain Future

In preparing for an uncertain future, a comprehensive strategy for defense research and engineering efforts becomes ever more critical. Investments in basic and applied science, technology development and transition, and in-house research capability are critical enablers of technological superiority, and by extension, operational advantage.

DARPA is central to our entire S&T effort. It is the innovation engine of the Department, with the latitude to attract the best scientific talent, and engage them on some of our most challenging problems. The high payoff technologies from DARPA projects have been the foundation of many capabilities and major weapons systems. The ability to look ahead of the technology curve to identify future challenges and high-payoff research areas that may not yet be recognized as critical by the larger defense community, and which will enable future warfighter capabilities, is a necessity. In this vein, the goal of DDR&E is to serve as an unbiased broker in setting the pace and priorities for research and engineering efforts across the Department in order to create options to shape the future, rather than react to it. Some examples of DDR&E research areas are listed below.

Airborne Laser (ABL)

An area where we have demonstrated breakthrough advances is in airborne laser technologies. In January of this year, the Missile Defense Agency demonstrated the first ever tracking and low power laser engagement of a boost phase target in the pacific missile range from the 747 Airborne Laser (ABL). In February this program demonstrated a full power boost phase intercept. To continue the development of future airborne laser concepts and capabilities, the ABL may serve as an airborne directed energy test-bed for the Department dependent on the results of an ongoing study directed by Secretary Gates.

Human, Social, Cultural, and Behavioral (HSCB) Modeling

The Human Social Culture Behavior (HSCB) Modeling program utilizes "soft power" derived from leveraging the soft sciences to provide innovative solutions. The program's ultimate goal is to put model-based tools in the hands of DoD personnel supporting intelligence analysis, operations analysis and decision-making, training, and joint experimentation. The HSCB Modeling program has engaged extensively with COCOMs and other operational users, leading to direct support to our Warfighters in Afghanistan and other operational objectives. Program investment has supported deployed users with greatly enhanced visualization capabilities, creation of a toolset to incorporate HSCB modeling factors into campaign planning for U.S. Army Training and Doctrine Command (TRADOC) and U.S. Army Special Operations Command (USASOC), and tools for determining regional stability.

Some current HSCB modeling projects are: The University of Chicago's Modeling Strategic Contexts, which supports the analysis of international conflicts by providing rich models of strategic context; Eastern Michigan University's Variations in Islamic Fundamentalism, designed to understand the factors influencing religious extremism and support for secular politics, gender equality, and national identity; Los Alamos National Laboratory's Simulation of Opium Supply Chain, which is developing models of adaptive decision-making in illicit cross-border supply chains; and TRADOCs Irregular Warfare Analytic Capabilities project developing methods, models, and tools (MMT) representing the Irregular Warfare (IW) operational environment.

Medical R&D and the Wounded Warrior Program

About 18 months ago, the Department conducted an extensive review of medical research and development. This review used the Joint Force Health Protection Concept of Operations to focus on key Wounded Warrior issues including Traumatic Brain Injury (TBI), Post Traumatic Stress Disorder (PTSD), prosthetics, and eye injury. As a result funding for this initiative was increased by nearly $500 million per year in the base Defense Health Program budget in FY 2010—a commitment that continues through FY 2011 and beyond. This initiative is making remarkable progress in such areas as understanding and mitigating brain injury and developing advanced prosthetics that restore greater functionality to our brave warriors.

The Department's medical R&D activities are centered on advancing the state of medical science, technologies, and practices in those areas of most pressing need to today's battlefield experience. The Department's major contributors to advancing military medicine are the Defense Health Program, DARPA, Army and Navy. Through the Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee, co-chaired by DDR&E and the Assistant Secretary of Defense(Health Affairs)[7], the Department ensures coordination and collaboration across the organizations contributing to the program. For FY 2011, the program will continue to have major investment focus in ten areas which include: psychological health, traumatic brain injury, prosthetics and rehabilitation, restorative eye-care, poly-trauma, medical radiobiology, medical information systems, medical training systems, and infectious diseases. Some examples of new wounded warrior efforts are: three Research Consortia for the study of the prevention, diagnosis and treatment of TBI/PTSD; two clinical trials on face reconstruction; innovations in photomedicine technology for eye injury and wound infection control; initiation of pilot programs to exchange health data with the US Department of Veterans Affairs and private health care systems; initiatives by the MIT Institute for Soldier Nanotechnology to map brain activity with varying sensory and motor stimuli; regenerative medicine initiatives aimed at restoring limb and organ function; investigation of the intersection of the physics of blast and the neurobiology of brain injury in blast environments; and development of improved control and fit of prosthetic arm devices.

Cyber Operations Research

Deputy Secretary of Defense Lynn recently highlighted the critical nature of the cyberspace domain by stating, "The Defense Department has formally recognized cyberspace for what it is - a domain similar to land, sea, air and space. A domain that we depend upon and must protect." [8] Furthermore, the QDR identifies the need to improve our capabilities to counter threats in cyberspace. Our military forces require resilient, reliable networks to conduct effective operations. The number and sophistication of cyber threats are rapidly growing, and the urgency and criticality of improving cyber security has become a national security priority. Many studies have documented the threats and the inadequacy of current approaches to the increasingly sophisticated adversaries. The problem is complex and asymmetric -- attackers often need to find just one vulnerability while the defenders must currently defend everywhere with multiple approaches. In order to meet the challenge of defending against and defeating the threat, new thinking and new research ideas are needed to build a more resilient and trustworthy cyberspace. Our cyber defenses must provide worldwide operational mission assurance during cyber attacks. Cyber network operations are an emerging warfare area and to succeed, our cyber defenses require sustained, innovative research to address the

[7] The ASBREM also includes the Surgeons General of the Services and Joint Staff

[8] U.S. Department of Defense, *Remarks at the Defense Information Technology Acquisition Summit As Delivered by Deputy Secretary of Defense William J. Lynn, III (Washington, DC),* http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1341 (Nov. 12, 2009).

constantly changing threats. DDR&E has advocated, driven, and coordinated efforts across the DoD for increased S&T in cyber security to develop enduring solutions to secure future military information systems.

Over the past few years DDR&E has brought together the DoD cyber research community to determine the DoD cyber S&T needs and priorities. Last summer, in response to the President's Cyberspace Policy Review, the Intelligence Advanced Research Projects Activity (IARPA) Director, Dr. Lisa Porter, and I launched a joint study in this area to identify high-payoff technology initiatives. This study, which was conducted with leading outside experts in the cyber security community, identified key areas of new research. These technology nuggets included new research to enable networks to operate through attacks, to establish security architectures for the many new mobile network devices, and to make the systems on our networks more difficult to find and target. Other new technology approaches were identified in virtualization to isolate untrusted programs, closed-loop software repair, and a new reference model for trusted computing. This and other studies, both classified and unclassified, have led to the development of a DDR&E new start program in Cyber Security Applied Research and Advanced Development.

The PBR-11contains two new, proposed DDR&E program elements to initiate a $200 million program over 5 years in applied research and advanced technology development for full spectrum computer network operations (CNO). This program will fund and transition the new research results. As the focus of the program, we have identified novel ideas to address the urgent S&T gaps in preparing for cyber conflict. The research problems are complex and joint, requiring the combined efforts of the Services and agencies. DDR&E has developed governance approaches that will insure a community-wide approach.

The DDR&E sponsored research will focus on developing new capabilities to:harden key network components; increase the military's ability to fight and survive during cyber attacks; disrupt nation-state level attack planning and execution; measure the state of cyber security; and explore and exploit new ideals in cyber warfare.

Through S&T investment in these areas, DDR&E will develop options for future capabilities to reduce vulnerabilities, reduce attack consequences, and reduce the threat from potential adversaries. While the details cannot be discussed in this forum, members of my staff have actively engaged with your Committee staff to describe the initial and ultimate plans for this program. We are committed to maintaining this visibility.

As part of the Comprehensive National Cybersecurity Initiative, DARPA is developing the prototype National Cyber Range (NCR). The National Cyber Range is envisioned to be a scientifically rigorous and realistic cyber testing platform. The NCR is intended to become a national resource for experimentation and testing of technology for both unclassified and classified cyber programs enabling leap-ahead advances in the US cyber capability. Upon completion, DARPA intends to transition this capability to broader use. Discussion of the transition strategy is ongoing.

The DDR&E staff has also played leading roles in the federal cyber security S&T planning and coordination. DoD laboratories are working with their civilian counterparts to support national efforts to secure cyberspace. These efforts contributed to the President's Cyberspace Policy Review, the National Cyber Leap-Year Summit, and the ongoing development of a federal cyber security research and development plan.

DDR&E has facilitated coordination and collaboration across the Services, DARPA and NSA by leading Steering Councils for both Cyber Security and Computer Network Operations S&T. DDR&E plans to use these groups as a mechanism to draw from technical resources across the entire Department. Coordination within these groups will ensure the Service laboratories, agencies, and partners executing the program work collaboratively to develop a robust portfolio of potential solutions to the large and complex problem of securing our networks and information systems. Looking forward, DDR&E will continue its facilitation role with other federal departments, agencies and international partners to more fully address the cyber security and information assurance challenges.

Electronic Warfare (EW) Technology Task Force

I chartered the Electronic Warfare (EW) Technology Task Force in response to concern that a common denominator among current and potential adversaries is a determined strategy to expand capabilities in the electromagnetic spectrum domain for offensive and defensive purposes. The mission of the EW Technology Task Force is to assess the military implications of the ubiquitous availability of high performance analog, digital, electro-optical, radio frequency and signal components, high performance signal and data processors, and increased ability to create sophisticated algorithms that will enable these systems.

The trend is clear: globalization of advanced electronic technology has made it easier for adversaries to develop effective EW capabilities, especially in a domain that is becoming increasingly congested by commercial competition for use. Additionally, we are seeing the convergence of underpinning technologies in areas such as space, cyber, electronic warfare and communications – areas traditionally considered to be independent. As a result, it will become more challenging and expensive for us to develop counter-capabilities if we continue to constrain ourselves to traditional development and acquisitions approaches and processes.

We must not only develop new concepts and capabilities to control and dominate the electromagnetic spectrum domain, but we must also be equally agile in fielding those capabilities. Success is crucial to the effectiveness of our forces. The EW Task Force findings are a first step in helping us identify potential solution paths.

Reduce the Cost, Acquisition Time and Risk of our Major Defense Acquisition Programs

In direct response to the Weapons Systems Acquisition Reform Act of 2009 (WSARA)[9], upon my arrival in DDR&E, the organization underwent a significant reshaping to more effectively address systems engineering, and developmental test and evaluation activities. USD(AT&L) Ash Carter recently testified that: "I support, as does the Secretary, the initiatives the Congress directed when it unanimously passed the Weapon Systems Acquisition Reform Act (WSARA) of 2009. Acquisition reform is one of DoD's High Priority Performance Goals presented in the Analytic Perspectives volume of the President's FY 2011 Budget. The Department is moving out to implement these initiatives." The following is how we are implementing WSARA as part of DoD's Acquisition Reform goal.

2009 Weapons Systems Acquisition Reform Act (WSARA)

The WSARA directed improvements on how the Department acquires major weapons systems in support of the warfighter. To that end, I have realigned the DDR&E organization to better staff and execute the necessary activities with the goal of ensuring that we, as a Department, reduce the cost, acquisition and time of delivery. Our Systems Engineering (SE) and Developmental Test and Evaluation (DT&E) Directorates are ensuring that the Defense Acquisition Board, Chaired by Dr. Ashton Carter, USD(AT&L), has relevant information prior to every milestone decision for MDAPs. Per WSARA legislation, our SE Directorate has also initiated a formal Development Planning framework to ensure we have a solid R&E foundation well before milestone A, and prior to the formal program initiation. The Development Planning process will mature over the next few months and will become a formal practice for all new acquisition programs.

WSARA vests new authorities and responsibilities in the Systems Engineering Directorate. It expands the sphere of oversight to include both systems engineering and development planning policy and guidance and adds the use of systems engineering approaches to enhance reliability, availability, and maintainability on MDAPs. Additionally, SE authorities for development and approval of Systems Engineering Plans (SEPs) were expanded to include oversight of all MDAPs. SE is currently defining application of development planning across the acquisition lifecycle, with particular emphasis on pre-Materiel Development Decision and Materiel Solution Analysis phase technical assessments to enable sound cost and schedule estimation of the preferred system solution presented to the Milestone Decision Authority at milestone A.

WSARA directs the SE and DT&E Directorates jointly submit an annual report to the congressional defense committees on the activities undertaken during the preceding year relating to each MDAP, which will include the program's fulfillment of the

[9] "Weapon System Acquisition Reform Act of 2009" (PL 111-23, 22 May, 2009)

prescribed objectives for the past year. The first annual report also includes analysis of Service SE and DT&E efforts and workforce.

Systems Engineering

Systems engineering is the interdisciplinary application of engineering tools, analysis, and techniques in a systems context. In all its activities, SE employs processes intended to reduce the cost, acquisition time, and risk of acquisition programs and to support the ultimate goal of delivering superior capability to the warfighter to prevail in current and future conflicts. It focuses on defining customer needs and required functionality early in the development cycle, documenting those requirements, and then proceeding with a structured process of design synthesis and system validation while considering the complete problem..

SE conducts detailed program reviews using a consistent, repeatable methodology (the Defense Acquisition Program Support Methodology) to advise program managers on risk and to provide mitigation recommendations, to inform DoD leadership of technical and engineering risks, and to provide milestone decision recommendations to USD(AT&L).

Emphasizing Early Life Cycle Systems Engineering

In accordance with WSARA direction, DDR&E is leading an effort to establish a Development Planning capability across the Department, and to establish technical leadership, authority, and engagement in the very early conceptual stages of the acquisition lifecycle. Development Planning comprises the upfront technical preparation to ensure the successful selection and development of a materiel solution. Development Planning policy, guidance and oversight, applied during early phases of acquisition, beginning with the Materiel Development Decision, will establish the foundation for our acquisition programs, and bootstrap our requirements and analytical processes with the engineering and technical engagement.

Developmental Test and Evaluation (DT&E)

DT&E is responsible for policy and guidance for the conduct of developmental test and evaluation in DoD. DT&E works closely with the Office of the Director, Defense Procurement and Acquisition Policy (DPAP) and the Office of the Director, Operational Test and Evaluation (DOT&E) to develop formal content. The policy and guidance are published in the Defense Acquisition Guidebook (DAG) and in DoD directives and instructions such as the Department of Defense Instruction (DoDI) 5000.02, "Operation of the Defense Acquisition System."

During FY 2009, DT&E engaged on the above-mentioned policy and guidance development in addition to publishing the guide Incorporating Test and Evaluation into DoD Acquisition Contracts, the Test and Evaluation Master Plan (TEMP) Guide, and the evaluation framework used for TEMPs. In addition, existing documentation includes policy and guidance on test and evaluation (T&E) for joint Military Departments and Agencies to support systems that provide capabilities for missions that must be tested in a

joint operational environment. Moreover, DT&E serves as Vice Chair to DoD's Testing in a Joint Environment Senior Steering Group, a formal governance body to oversee the implementation of the DoD Testing in a Joint Environment Roadmap.

According to statute and policy, DT&E reviews and jointly approves the TEMPs and Test and Evaluation Strategies (TESs) for all MDAPs and other programs on the OSD T&E Oversight List in coordination with Director, Operational Test and Evaluation (DOT&E). DT&E also coordinates with SE to ensure DT&E activities are integrated and consistent with systems engineering and development planning. Since July, the office has approved 23 TEMPS and assisted component test development planning on 76 programs. Efficient, well-planned test programs are essential for rapid fielding capability in support of current operations.

Technology Readiness Assessments

The final element of the WSARA legislation was the expansion of the application of Technology Readiness Assessments (TRAs). In recent years, there has been increasing recognition, both inside and outside of the Department, that efforts to begin system development with immature technologies incur higher risk. The DoD, Government Accountability Office, and Congress have all recognized the fundamental role that mature technologies play in defense acquisition program success.

Technology Readiness Assessments have been used by USD(AT&L) to support DoD acquisition decision-making, and to certify technology maturity at Milestones B and C, and they have been effective in the identification of technology readiness issues prior to acquisition decision points, thereby focusing attention on mitigating any such deficiencies. In some cases, immature technologies have been identified that led to additional technology testing and validation in operationally relevant environments. TRAs have also clarified ambiguities in system requirements that might otherwise cause serious problems and delays during program execution. Lessons on how to conduct more effective assessments are being continually learned from past assessments, and are captured in the TRA Desk Book to assist current and future acquisition programs.

During calendar year 2009, DDR&E completed 11 TRAs of MDAPs, and 1 special assessment. Numerous other TRAs progressed at various stages of the rigorous process employed by DDR&E and Service Acquisition executives. Among the MDAPs assessed were Standard Missile-6 (SM-6), Warfighter Information Network-Tactical (WIN-T), and Joint Tactical Radio System Wideband Networking Waveform (JTRS WNW). In every case, an Independent Review Team (IRT) serves as a key element of the TRA process. The IRT is charged with identifying critical technology elements, and objectively evaluating evidence of technological readiness relative to the specific requirements of the MDAP in question. IRT results are then carefully evaluated by DDR&E, and the results are used to shape upcoming acquisition decisions. As a result of WSARA direction, DDR&E will expand the use of TRAs to conduct periodic examinations of selected MDAPs that passed Milestone B three or more years previously to ensure prompt visibility into potential risks associated with technology maturity.

Develop World Class Science, Technology, Engineering, and Mathematics (STEM) Capabilities for the DoD and the Nation

Preparing the Department to manage complex science and technology challenges requires building and shaping a highly-qualified science, technology, engineering and mathematics (STEM) workforce. This drives DDR&E's fourth imperative: to develop necessary STEM capabilities for the Department and the Nation.

To provide context and to initiate thought leadership for this imperative, DDR&E convened a STEM Board of Directors consisting of 27 senior leaders from across the Department. One of their first activities was to guide the development of a STEM strategic plan for the Department. The STEM Board of Directors' charter is to inspire, develop and attract the talent in STEM disciplines essential to deliver innovative solutions for the Nation's current and future challenges. The strategic plan is intended to guide the series of initiatives that support the DoD STEM program portfolio, and respond to the short-, medium- and long-term STEM needs of the Department across the Services and components.

National Defense Education Program (NDEP)

To augment the policies of the STEM Board of Directors, we have increased our FY 2011 President's Budget Request for the National Defense Education Program (NDEP). NDEP codifies and funds authorities granted in the FY 2005 Authorization Act.

In 2009, the Science, Mathematics And Research for Transformation (SMART) program provided full scholarships to 250 high-performing STEM students who will come work for the DoD immediately after they graduate. By the end of this year, nearly 300 SMART students will have transitioned to DoD laboratories and other components.

NDEP's K – 12 component contributes to enhancing teacher quality in STEM and increasing student involvement in science and engineering activities. DoD laboratory scientists and engineers work with classroom teachers and their students in their local communities.

The third component of NDEP, the National Security Science and Engineering Faculty Fellowship (NSSEFF) supports U.S. investments in basic research and creates collaboration between academia and the government. Since 2008, the NSSEFF program has made awards to 29 high-performing distinguished faculty to conduct revolutionary research that is critical to the DoD and national security. Two important features of NSSEFF that are providing additional benefit to DoD are the direct engagement of Fellows and their teams of undergraduate, graduate and and post-doctoral scholars with our scientists and engineers; and the inclusion of these talented technical teams in DoD research-focused workshops.

Historically Black Colleges and Universities / Minority Institutions (HBCU/MI) Program

The DoD Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) program is designed to inspire young people to pursue studies and careers in science, technology, engineering and mathematics to address future national security challenges.

Through the HBCU/MI program, DoD not only supports promising research at these institutions but also seeks to increase the cadre of individuals that pursue STEM disciplines as a career. Graduates of these institutions contribute to diversity in this pool nationwide across the research sector. Some graduates, including those who have had had an opportunity to participate in DoD programs through research opportunities at DoD laboratories as part of the HBCU/MI program, may become DoD employees.

For the 2 year period ending in July 2009, DoD provided funding for more than 460 undergraduate and graduate students at HBCUs/MIs. Of that number, almost 30 percent graduated with degrees in STEM and many of them expect to pursue graduate or post-graduate work. Some expect to work for DoD, while others will pursue STEM careers in other research settings. An example of the above is the John Hopps Defense Research Scholars program at Morehouse College, which currently supports 100 STEM students. The first class of 20 scholars under this program will graduate in May 2010.

A Look Ahead

Beyond the FY 2011 President's Budget Request, we are beginning to frame concepts in two key areas that will have critical importance for the Department and for our Nation in the next decade. We are polling the user and technical community to frame future efforts in 'Data-to-Decisions' and 'Systems 2020' that are needed to address aspects of all of the QDR mission areas.

Data-to-Decisions

The purpose of this initiative will be to develop technologies to manage the massive data sets being piped around our operational theaters while also providing actionable decision tools for our leadership. Recently Lieutenant General Dave Deptula, the Air Force Director of Intelligence recognized, "we are swimming in sensors and drowning in data"[10]. New sensing capabilities are now emerging that generate significantly more data than all our currently fielded UAVs combined. The S&T community has been successful in giving our forces a data advantage; now the challenge is to deliver a decision advantage. We will examine handling, fusing and exploitation of these massive data sets and other innovative approaches for the distribution, storage and efficient retrieval schemes. Our goal will be to advance data analytics to allow data to be fused with relevant contextual or situational information to provide our warfighters and decision makers with insight and powerful decision aids.

[10] LtGen David Deptula, USAF. (2009). Speech content. October 2009. *C4ISR Journal* Conference, Arlington, VA

Systems 2020

The second overarching initiative – Systems 2020 – is designed to give the DoD S&T and manufacturing communities a decisive edge in the design and manufacture of complex systems. Over the past years, the Department's research and development efforts have successfully resulted in the delivery of high performance software and hardware components, but at a cost of increasing system complexity. Like the commercial sector, the DoD needs to adapt to the growing complexity of our major acquisition systems while managing cost, schedule and performance risk throughout the lifecycle. These very complex systems must be adaptable to changing environments and interoperable with other fielded systems to ensure optimum delivery of capability to our warfighters and value to our taxpayers. The Systems 2020 initiative will be a Department-wide effort to develop new system engineering foundations for the next decade in basic research, applied research, prototype development, and workforce development. When realized, the new tools and processes will enable a number of new design, development, and manufacture capabilities across the DoD acquisition enterprise.

Summary

With the support and guidance from our DoD leadership and Congress, we have made significant progress reshaping the Department's research and engineering enterprise using the coordinates of innovation, speed and agility as our metric. We have teamed with industry, academia and our own DoD laboratories to form the Research Triple to ensure our most talented technical minds are addressing the technology challenges currently posed by our Warfighters while remaining adaptive to future requirements. Within this context, the FY 2011 President's Budget Request for science and technology was developed to support Department-wide efforts to provide technological solutions, identify strategic threats and develop improved capabilities is critical in support of our national security. To maintain our technological advantage on the battlefield, we have reinvigorated STEM initiatives and programs designed to inspire, develop and attract the talent essential to deliver these innovative solutions. The combination of first rate people and compelling ideas will continue to drive our innovative engine and ensure our Nation continues to maintain a competitive edge on the battlefield. Thank you for the support of the DoD S&T enterprise and I appreciate this opportunity to provide the committee with an update on the status of the DoD S&T enterprise.

STATEMENT BY

DR. THOMAS H. KILLION

DEPUTY ASSISTANT SECRETARY OF THE ARMY

FOR RESEARCH AND TECHNOLOGY

AND CHIEF SCIENTIST

BEFORE THE

SUBCOMMITTEE ON TERRORISM,

UNCONVENTIONAL THREATS AND CAPABILITIES

COMMITTEE ON ARMED SERVICES

UNITED STATES HOUSE OF REPRESENTATIVES

ON

THE UNITED STATES ARMY'S SCIENCE AND TECHNOLOGY (S&T)

PROGRAM FOR FISCAL YEAR 2011

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UNITED STATES HOUSE OF REPRESENTATIVES

STATEMENT BY
DR. THOMAS H. KILLION
DEPUTY ASSISTANT SECRETARY OF THE ARMY
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Madam Chairwoman and Members of the Subcommittee, thank you for having me here today to discuss the fiscal year (FY) 2011 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're grateful to the members of this Committee for your sustained support of our Soldiers especially in this time of war, and for the funding of investments that will provide our future Soldiers with the equipment and capabilities to defend America's interests and those of our allies around the world.

The Army's S&T investment strategy is shaped to foster innovation while we accelerate and mature technologies that enable Future Force capabilities and exploit opportunities to rapidly transition technology to the Current Force. The S&T program retains flexibility to be responsive to unforeseen needs identified through current operations. We have rapidly responded to a broad range of needs by leveraging our technology investments in future capabilities and our workforce expertise to address emerging issues.

I would like to take the opportunity today to focus on some important areas of investments for our future force, as well as important issues relating to the most critical part of the Army S&T enterprise--our workforce. Our major investments in the core S&T program are best understood in terms of technology areas. The following paragraphs highlight our investments within five of these key areas:

Force Protection Technologies

The Army's S&T community is developing both active and passive protection technologies that increase the survivability of Soldiers, platforms and facilities/bases. This includes the ability to track, engage, and defeat rockets, artillery rounds, and mortars; detect and neutralize Improvised Explosive Devices (IEDs)/mines; and protect against traditional threats to tactical and combat vehicles. Major investments in Force Protection include the development of new materials, physics-based models, and armor formulations for increased ballistic protection at reduced weights for both Soldier and platform applications; the development and demonstration of a suite of active and

passive protection technologies to maximize the survivability of lightweight vehicles and rotorcraft; active protection countermeasures against Kinetic and long-range Chemical Energy munitions for combat vehicles; and protection for installations against rockets, artillery, and mortars.

In keeping with the practices of counter-insurgency operations such as those applied in Afghanistan and Iraq, military forces are frequently located in close proximity to the locals (or people) whom we are endeavoring to secure. Force protection at smaller, remote bases and those integrated within or nearby local communities offers particular challenges that can differ from those force protection challenges posed at the larger bases. The Army S&T community is leading a Deployable Force Protection initiative on behalf of the Department of Defense to address these challenges, with an additional investment of nearly $170 million over FY11-15. This effort is focused on providing integrated, interoperable and scalable base protection capabilities, including standoff detection, ballistic protection and fire/defensive solutions. The objectives of the initiative are threefold - identify promising technologies for near-term solutions that meet identified needs; inform future S&T investments; and establish a Red Teaming capability to generate insights into technology robustness and product improvements. With this additional investment, Army S&T is spending approximately $250 million from FY11-15 on technologies to protect our troops as they deploy in Iraq, Afghanistan and other areas around the world.

C4ISR Technologies

Investments in this area enable networked surveillance and decision aids for collaborative, real-time, mission planning, on-the-move operations, and networked lethality particularly in complex urban environments. These investments also pursue technologies to enable secure, mobile, ad-hoc networks for sustained high op-tempo, full spectrum operations; infrared (IR) sensor technologies for extended range detection and identification; and airborne imaging/moving target identification radars. Specific technology investments include software and protocols for secure, mobile, ad-hoc networks; third generation infrared imaging sensors; and tactical decisions aids that incorporate geo-spatial and cultural information into the Army's Battle Command systems to enable better predictive analysis capability. These technologies are essential for maintaining comprehensive situational awareness, effective allocation of resources, and supporting rapid decision making in the challenging environments we face in irregular warfare.

For FY11, the Army is making significant new investments in Infrared Focal Plane Array (IR FPA) technology. With efforts in both cooled and uncooled FPA technology, these

investments will reduce costs through new detector materials and designs and improve overall performance by enabling the development of high-definition (HD) sensors critical for targeting, persistence surveillance, 360 degree day/night situational awareness, and HD night vision. Again, the Army's S&T community has been asked to lead this FPA initiative on behalf of the Department of Defense. In FY11-15, the Army's FPA investment is increased by $94 million to result in an overall investment of over $160 million in the next five years to develop applications that will be used throughout the Department of Defense. This focused investment ensures the United States' pre-eminence in this technology area and dominance on the battlefield.

Medical Technologies

Our investment in medical S&T provides the basis for maintaining the physical and mental health of Soldiers as well as enhancing their performance. Investments in this area improve health protection, treatment, and life-saving interventions for Soldiers. This program has three components: combat casualty care (inclusive of blast trauma from explosive devices); military operational medicine (to enable effective performance under environmentally extreme conditions worldwide); and infectious disease (diagnosis, treatment, and preventatives).

Of particular note is the Army's S&T investment in regenerative medicine that has achieved great success through the regeneration of human tissues and organs. The Army, with the help of the Navy, Air Force, Veterans Health Administration, and the National Institutes of Health, has established the Armed Forces Institute of Regenerative Medicine (AFIRM). The AFIRM consists of over 200 scientists in 27 Universities and the US Army Institute of Surgical Research. AFIRM was established primarily to discover better ways to prevent and treat damage due to burns and to develop methods that allow the regeneration of nerve, bone, and muscle tissue in those warriors who have serious tissue loss. This capability has great potential for treating military personnel with disfiguring and disabling injuries. Regenerative medicine uses tissue engineering to prompt the body to regenerate cells and tissues, often using the patient's own cells combined with degradable biomaterials. The ultimate goal of this effort is to regenerate entire limbs.

Approximately 900 Soldiers, Sailors, Airmen and Marines have lost limbs in Operation Iraqi Freedom and Operation Enduring Freedom, the preponderance of these losses being to members of the Army. While Soldiers usually adapt well to leg prostheses, upper extremity prostheses are not accepted as well. Approximately 40% of upper extremity amputees choose not to wear prosthesis, describing the apparatus as "too much of a bother."

In the AFIRM's first clinical trial on limb replacement, a Marine received the first hand transplant in the world where bone marrow-induced immune tolerance was instituted. Through the use of a novel immunosuppressant regime, donor bone marrow was transplanted at the same time as the hand. The donor bone marrow, coupled with novel immunosuppressant drugs, induced a tolerance of the transplanted hand that exceeds any previously attained. As a result, the patient has been weaned to only one immunosuppressant drug instead of the customary three. AFIRM has also performed a double hand transplant with similar results. A transplanted limb allows wounded warriors to regain function of their limb over time.

Soldier System Technologies

Our investments in Soldier technologies seek to provide individual Soldiers with "platform-level" capabilities. The goal is to seamlessly link Soldiers to sensors and platform-based lethality capabilities in real time -- to accurately identify and engage targets with greater precision lethality. All enhanced Soldier capabilities are developed with the load each Soldier must carry in mind. Key Soldier technology investments are approached in a holistic method to address personnel load issues. Efforts focus on both materiel and non-materiel solutions by evaluating the critical aspects of physical, biomechanical, psychomotor and cognitive aspects of the Soldier load. Tradeoffs acknowledge the Soldier's need to balance the limits of human performance with his need for situational awareness, agility and mobility in complex terrain. Investments include: the development and integration of advanced lightweight materials into Soldier-borne equipment; modular protection components allowing for "in the field" Soldier-load tailoring based on threat analysis; and energy efficient electronic equipment designs powered by high density power sources with the capability to exploit battlefield generation of power for recharging. As the emphasis on deployed forces is placed more on light infantry-type operations, continued investment and maturation of materials and processes to lighten the load on individual Soldiers is paramount to a target goal of achieving true fighting load weights for all Soldiers regardless of specialized weapons or communications.

Human Dimension

The Army S&T community continues to investigate technologies that can assist and support the physical and cognitive capabilities of the Soldiers to perform in full spectrum operations. To this end, we invest in areas such as the social sciences to help better understand the environments and cultures within which we operate. We develop training tools that provide the Soldiers with more effective ways to prepare for interactions within the complex environments and situations within which he will fight

and/or provide stability. In addition we develop methods to more effectively select Soldiers and leaders within the Army and better, more effects methods of training. This effort leverages much of the work that is done within the Social Sciences as a way to underpin our training tools. We assess the effectiveness of immersive training, embedded training and live, virtual and constructive training events. In FY11-15, you will see an increase in the Army's investments to leverage on-going DoD-wide activity in the social/cultural venues, as well as increases to develop, evaluate and validate training methods and tools such as those used in large scale distributed training and Post-Traumatic Stress Disorder (PTSD) treatment.

Basic Research

Essential to realizing superior land warfighting capabilities is the discovery of new fundamental knowledge through high-risk/high-payoff basic research in areas highly relevant to the Army mission. To accomplish these goals the Army maintains a robust basic research program that extends across a variety of disciplines, leveraging some of the best minds in the country.

I will highlight of few of the disciplines in which we have elected to increase our efforts. In FY11, the Army will increase its focus on developing the scientific foundations leading to the discovery of novel materials with extraordinary performance characteristics of particular interest to the Army, such as ballistic protection. The robust research approach will emphasize multi-scale modeling and simulation for performance prediction and design of materials under extreme conditions (high strain rate, temperature, pressure, etc.). This modeling effort, supported by in-house and extramural experimental studies, will study a range of material classes (such as structural, electronic, energetic) and coupled disciplines (e.g., mechanics and electromagnetics) enabling two-way information transfer across the length scales from the molecular level up to the material system level.

In a parallel effort, we will initiate new research into the characterization of chemical and biochemical phenomena occurring at or near solid surfaces and interfaces. This research will include studies of the interplay between chemical reactions and transport processes on surfaces, developing theory and models leading to the understanding and prediction of fundamental physical and chemical processes at complex surfaces and interfaces. This materials and surface/interface research will lead to new methods and materials for a broad range of potential applications across the Army including force protection for Soldiers, platforms and facilities.

In order to meet the ever increasing power needs of the future force, and in particular the dismounted soldier, we have increased FY11 research funding to pursue new compact power and energy sources. This research will explore new materials and processes leading to more efficient energy sources, energy storage, energy harvesting, and energy conversion capabilities. The approach will leverage the high-performance computing capabilities within the Army laboratories in combination with extensive experimental efforts to predict characteristics and performance *a priori* for energy generation, storage and conversion materials. This multidisciplinary approach will also investigate emerging nanostructured materials such as carbon nanotubes, graphene, silicon carbide, diamond, as well as bio-inspired approaches to harvesting or generating electrical power.

Recently, President Obama has stressed the need for increased national attention to building our capabilities in the fundamental sciences to ensure our nation remains a global leader in technology. In response to this call, the Army has expanded its support for university research and research education of students through its competitive single investigator program. This increased investment 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. This expanded university investment will engage the best and brightest professors and graduate students across the U.S. academic community. The increased funding could support as many as 45 additional graduate students per year, helping the U.S to maintain its lead in cutting-edge research and ensuring that the Army and the nation has the talent needed to not only maintain but rather grow our future workforce of scientists, engineers and mathematicians.

Laboratory Infrastructure and Science and Engineering 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 Research, Development, and Engineering Centers. This is challenging because the Army must compete with the other Services as well as the private sector to obtain its future workforce. We have taken important steps to attract and retain the best science and engineering talent. Our laboratory personnel demonstrations have instituted initiatives such as pay banding to enhance recruiting and afford the opportunity to reshape our workforce. These initiatives are unique to each laboratory, allowing the maximum management flexibility for the laboratory directors to shape their workforce and remain competitive with the private sector. In December 2009, final Federal Register Notices

were published for laboratory demonstrations at the Natick Soldier Research, Development and Engineer Center (RDEC) and the Edgewood Chemical Biological Center; this is the last step in the approval of their lab demo plans. The Armament RDEC and Tank Automotive RDEC are preparing plans for their laboratory personnel demonstrations.

The Army has also instituted direct hire authority for scientists and engineers (S&Es) with advanced degrees at our demo laboratories, and we would like to thank the Committee for their strong support on this issue. The Army laboratories have hired 34 talented S&Es using this authority since June 2009, and the laboratory directors intend to use this authority to the fullest extent possible this year. The Research, Development and Engineering Centers are also taking advantage of the enhanced hiring authority for acquisition personnel.

To maintain technological superiority now and in the future, the Army needs to maintain state-of-the-art laboratory facilities and attract top quality scientists and engineers. 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, providing new facilities and capabilities. This authority has enabled the Army to fund 13 minor milcon projects in FY08 and to initiate 15 projects in FY09. Of the total, twelve of the efforts were for revitalization of the Army laboratories; the remainder will provide improved test and evaluation facilities. Additionally, we are continuing to work on the implementation of the Section 219 authority provided by Congress. This authority will give the labs additional flexibility to use funds in innovative ways, both for conducting research and for upgrading facilities. We fully support this authority, and look forward to working with the Committee to further develop it going forward.

Finally, we believe that strong science, engineering and mathematics education at all grade levels is critical to both the ongoing success of the Army S&T enterprise and the nation as a whole. Army S&T contributes to this future success through the Army Educational Outreach Program (AEOP) which comprises 21 outreach efforts, either through direct oversight or through active participation. In the 2008-2009 academic year, AEOP received over 76,000 student applications, engaged nearly 7,000 teachers, involved 430 universities and utilized the experience and personal commitment of over 1,200 Army scientists and engineers. For FY10, efforts are concentrated on ways to expand the reach and influence of successful existing programs by leveraging partnerships and resources with other services, agencies, industry and academia. 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 is currently out for solicitation. The Army envisions the Educational COA will bring

together government and a consortium of organizations working collaboratively to further Science, Technology, Engineering, Mathematics (STEM) education and outreach efforts nationwide.

Conclusion

The S&T portfolio continues to contribute to addressing the Army's critical challenges and restoring balance in our forces. Given the current demands on Army resources from ongoing overseas operations, and our desire to be good stewards of taxpayer dollars, the Army S&T community addresses the issue of affordability wherever possible. Increasingly sophisticated capabilities come at a price. The S&T community is seeking to drive down system costs for the Army through deliberate technology initiatives that focus on replacing high-cost components in existing systems, merging multiple capabilities into single systems and developing manufacturing processes that reduce overall production and assembly costs. We will continue to look at issues of affordability as the Army modernizes.

With the continued support of Congress, the Army will be able to maintain funding for a diverse S&T portfolio that is adaptive and responsive to unanticipated needs of the current fight while still achieving the desired capabilities for the Future Force.

The Army's scientists and engineers are expanding the limits of our understanding to provide our Soldiers, as well as our Joint and coalition partners, with technologies that enable transformational capabilities in the ongoing Overseas Contingency Operations to ensure that the Army remains a relevant, ready and victorious land component of the Joint Force. The Army S&T community is the "engine" of change for the Army's transformation.

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HOUSE ARMED SERVICES COMMITTEE
TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE

STATEMENT OF
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CHIEF OF NAVAL RESEARCH

BEFORE THE
TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE
OF THE
HOUSE ARMED SERVICES COMMITTEE
ON
THE FISCAL YEAR 2011 BUDGET REQUEST

MARCH 23, 2010

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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 2011 Budget supports the Navy and Marine Corps. The President's FY 2011 Budget requests $1.96 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. Throughout the past year, the Office of Naval Research (ONR) continued a direct, hands-on partnership with the Chief of Naval Operations (CNO) and Commandant of the Marine Corps (CMC). We believe that to address critical challenges facing the Navy and Marine Corps, ONR must: 1) focus on S&T areas that provide the biggest future payoff, 2) be innovative in thinking and business processes, and 3) continue improved transition of S&T into acquisition programs.

S&T Strategic Plan

The updated Naval Science and Technology Strategic Plan, approved last year by Navy and Marine Corps leadership, reaffirms 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 Marine Corp requirements: 1) Power & Energy, 2) Maritime Domain Awareness, 3) Operational Environments, 4) Asymmetric and Irregular Warfare, 5) Information Superiority & 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.

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).

Discovery & Invention

Discovery and Invention (D&I) includes basic research (6.1) and early applied research (6.2) in areas with unique requirements or capabilities essential to the Naval mission. D&I develops fundamental knowledge, provides the basis for future Navy/Marine Corps systems, and sustains the Defense Scientist and Engineer workforce.

Approximately 40 percent of S&T investment is in D&I in order to sustain basic and early applied research. 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 builds the foundation of our S&T portfolio by developing 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, and all programs are peer reviewed.

An important element of D&I is the Defense University Research Instrumentation Program (DURIP), which supports university research essential to Naval research. DURIP complements Navy 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, and plans to award 61 grants in FY 2010. Another D&I program, ONR's Basic Research Challenge, stimulates interdisciplinary research in emerging S&T fields.

D&I investments also support development and sustainment of the S&T workforce. 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 our Warfare Centers. Education and research opportunities for undergraduate and graduate students, fellows, future faculty members and researchers are provided through programs, such as the Naval Research Enterprise Internship Program (NREIP), which expose participants to work done at Naval laboratories.

Through the University Research Initiative (URI) and Young Investigators Program (YIP), ONR gains access to researchers with an understanding of, and willingness to investigate high priority topics of interest to the Navy that intersect multiple technical disciplines. In addition, we continue to support Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) with research and education partnerships. Through demonstration, apprentice, award, and graduate programs, we encourage young people to explore S&T careers in academia, Naval labs, and industry. ONR is now the coordination center for all Navy Science, Technology, Engineering and Mathematics (STEM) educational activities.

In addition to external research, ONR supports research at 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 within our in-house laboratory.

Innovative Naval Prototypes

Innovative Naval Prototypes (INP) represent approximately 10 percent of the S&T budget. They 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 six current INPs:

The Tactical Satellite (TacSat) INP will be completed in FY 2010. The TacSat challenge was to build microsatellites demonstrating technologies that help close existing Naval warfighting gaps, provide quick and responsive access to space, as well as easy access to the tactical commander. With six payloads completed, most technology transitions to the Operationally Responsive Space program office in New Mexico.

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 EMRG program continues to achieve technical objectives while moving toward scheduled completion of Phase I in FY 2011.

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. We expect PLUS to complete by FY 2012.

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 three design teams for incorporation into their technology development. We are in Phase II of a three phase program, concluding with prototype construction and demonstration in FY 2013.

The Free Electron Laser (FEL) INP will bring laser technology to sea for ship defense against a variety of threats. Consistent with plans for an all-electric ship, the FEL INP will develop a laser tuned to atmosphere-penetrating wavelengths for use in maritime environments. This will allow us to assess the potential of laser-based shipboard defense that includes tracking, discrimination, countermeasures, and scalable direct fire at the speed of light.

The Integrated Topside INP will enable Navy to dominate the electromagnetic spectrum through development of multifunction apertures for all ship classes. We are also 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.

Future Naval Capabilities (FNCs)

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). As opposed to high-risk/high-payoff INPs, FNCs are near-term projects included in the part of our budget focused on Acquisition Enablers (approximately 30 percent). The FNC process delivers

mature technologies to acquisition sponsors for timely 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 that can 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. We have had good success in this effort and expect continued strong performance in 2010.

Increases and Decreases in FNC Funding Levels

It is important to remember: FNC investments focus on the most pressing capability gaps, generating year-to-year changes in funding for associated Program Elements (PEs). As FNC investments mature and develop over 3-5 years, Technology Readiness Levels (TRL) change, moving products from 6.2 to 6.3 PEs. The first year is predominantly 6.2; the final year is predominantly 6.3 – with a mix of 6.2/6.3 in-between. As products deliver and 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.

Current S&T Program Highlights

The Naval S&T portfolio includes a range of projects entering the fleet 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.

Manpower, Personnel, Training and Education

In FY 2011, ONR's Capable Manpower FNC is focused on developing innovative, technology-based products to support Navy/Marine Corps Human Capital programs, including manpower,

personnel, training, and human systems design products. These will optimize performance, minimize ownership costs, and ensure systems are built to accommodate characteristics of the user population that will operate, maintain, and support the systems and the warfighters.

In support of *Strategy for Our People 2016*, Capable Manpower will develop a suite of integrated decision support analytical tools to assist managers to forecast and assess the effects of enlisted and officer behavior (recruitment, retention, career decisions, education benefits, etc.) resulting from both current and proposed Navy policies. These tools will help meet the CNO and SECNAV goal of creating a more agile, competency-based workforce that integrates the total force and adopts personnel policies to make Navy competitive in the marketplace.

Another Capable Manpower program goal is to improve availability and reliability of critical information needed by the Commanding Officer and team to make better-informed decisions. To achieve this goal, the program will develop innovative information architecture for future combat control rooms by blending key elements of information processing, team structure, display techniques, and training interventions. Design will be driven by the most critical information requirements of decision makers.

This program will improve operational decision making as a result of transforming command team information flow from data-centric architecture that requires 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.

The program will also develop and demonstrate validated, effective, adaptive training prototype systems to enhance individual and team training. Adaptive systems impart adaptive expertise to the learner – including intuition, creative thinking, problem solving skills – while compressing the learning experience by optimally tailoring experiences, in real-time, to current cognitive and physiological states of the learner.

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.

Marines and Sailors as a System

Marine Corps S&T is coordinated and executed by ONR and the Marine Corps Warfighting Laboratory. These organizations develop and transition technologies to enable the Navy-Marine Corps team to win and survive on battlefields of today and tomorrow. When addressing technologies, the individual Sailor and Marine are treated as a "system". Sailors and Marines are the heart and soul of the Navy and the Marine Corps and together provide the nation a Naval expeditionary force fully prepared for employment across the spectrum of operations. Technologies being pursued today will enable future Naval forces to respond whenever our

country is threatened, to arrive on the scene on short notice anywhere in the world via amphibious ships of the Navy, and to fight and win our nation's battles.

Infantry Immersion Trainer

The Infantry Immersion Trainer (IIT) is a revolutionary training system that prepares Marines and Sailors for deployment to today's battlefield environment. The facility uses virtual reality, physical structures, gaming avatars (virtual characters), 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, yet realistic, training environment for learning how to prevent fatal errors before being exposed to real threats, with the goal of making the first fire fight no worse than the last simulation.

IIT software allows rapid improvement of training delivery, with simulated scenarios tailored to suit mission or individual needs. Repeatable, scalable scenarios increase skills in less time. Our first IIT facility opened in 2007 at Camp Pendleton; a second is planned for Camp Lejeune in 2010. The IIT incorporates ONR technologies, Defense Advanced Research Projects Agency's (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 improve IIT software, conduct IIT experiments, and is Technical Manager of the Future Immersive Training Environment (FITE) Joint Capabilities Technology Demonstration (JCTD) which will improve the IIT for a demonstration in September 2010.

Marines in Operational Environments

Marines must be able to destroy enemy formations with scalable air-ground-logistics teams in major contingencies, and be equally able to employ superior Irregular Warfare (IW) skills. ONR has taken the lead in balancing traditional and IW capabilities by providing quantifiable technical advantages to warfighters in Afghanistan and Iraq. 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.

In implementing *Marine Corps Vision and Strategy 2025*, Marine Air-Ground Task Forces (MAGTF) of the future, either from the sea or in sustained operations ashore, must be leaner in equipment. ONR initiatives will help reduce the load of Marines and Sailors through materials and technologies that are much lighter, while providing enhanced protection in combat.

We have initiated a focused technologies approach designed to lighten the load of the individual Marine and lighten the footprint of the Marine Air-Ground Task Force (MAFGTF). Depending on the situation, and including helmet, body armor, weapons, water, ammunition, and batteries, the weight of gear for a Marine on foot-patrol in Afghanistan can average 90 pounds. There is a

delicate balance between weight and protection, and ONR continues to pursue the latest technology to provide Marines with scalable protection based on mission and threat.

Persistent intelligence, surveillance and reconnaissance technology will provide tactically relevant information in all phases of a broad spectrum of operations. It will enhance situational awareness and understanding – enabling real-time decision making that provides proactive, predictive capabilities for Asymmetric and IW, as well as traditional encounters.

The use of unmanned aerial cargo vehicles to rapidly move logistics on a distributed battlefield and complete casualty evacuation, as well as revolutionary robotics to enhance ground logistics delivery, are future capabilities equally applicable to IW and traditional warfare.

ONR has been in front of efforts to improve survivability for the Marine Corps current and future family of 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 help make Marine Corps forces more agile, lethal, mobile and survivable.

Large Scale S&T Demonstrations for Protection of Ground Forces and Systems

As we reported last year, major integrated technology demonstrations are investigating dramatic new capabilities in the Protection of Ground Forces and Systems. The demonstrations are wide ranging, encompassing technologies for pre-detonation of Improvised Explosive Devices (IEDs), personal protection materials and power generation, micro power sources, and augmented reality.

The integrated demonstration program will be a multi-year effort to both investigate technology integration, and spur application of fundamental technologies for force and platform protection. The integration of safer ways to remotely detonate IEDs will require additional power – while technologies to enhance the protection capacity of equipment that mitigates blast effects, blunt trauma, ballistic and directed energy attacks will require new materials and nanomaterials.

Advanced power systems for dismounted Marines will be embedded in the demonstrations. Power systems include advanced batteries, fuel cells, and personal power. Augmented reality will demonstrate fusion of organic and individual borne sensors with existing datasets to provide enhanced decision systems and situational awareness. Resulting successful force protection applications and technologies will see immediate utilization.

An example of technology that already emerged from the integrated technology demonstrations is the Gunslinger Package for Advanced Convoy Security (GunPACs). This program is executing a rapid prototype development strategy coupled with planned system deployment with Marines in Afghanistan this fall. GunPACs provides enhanced situational awareness for ground and logistics elements conducting combat operations. This vehicle mounted technology provides accurate targeting solutions for small units and logistics convoy crews enabling them to effectively and discriminately engage enemy forces with remote weapons while remaining under armor.

Non-Lethal Weapons and Technology Development

The Marine Corps is the nation's expeditionary, combined-arms force. Expeditionary connotes speed, lethality, rapid deployment by air or sea, and efficient, effective operations in an austere environment. This means a task-organized force that is manned and equipped no larger or heavier than necessary to accomplish the mission. Expeditionary means being prepared for decisive action, but also possessing non-lethal capabilities when required.

Non-lethal weapons are devices and munitions explicitly designed and primarily employed to incapacitate targeted personnel or materiel while minimizing fatalities, permanent injury, and undesired damage to property in the target environment. Non-lethal weapons are intended to have reversible effects on personnel and materiel, and include technologies that deny access to individuals, disable vehicles, and entangle vessels. They provide a capability to defend against threats and control crowds, while providing standoff protection for friendly forces. To support the Commandant of the Marine Corps in his role as Executive Agent for the Joint Non-Lethal Weapons Program, a broad spectrum of counter-personnel, counter-materiel, non-lethal weapons are under development at ONR.

Operational Adaptation

As we described last year, Operational Adaptation (OA) is intended to identify, develop, and demonstrate S&T solutions for future conflict. These conflicts, called "hybrid complex warfare" or "hybrid complex operations" may include all elements of conventional, irregular, disruptive, or catastrophic threats. Recognizing that adversaries are adaptive, rather than try to predict the exact threat and counter that prediction, OA provides warfighters with capabilities to develop and sustain a tempo of adaptation and decision-making superior to any adversary. OA anticipates fighting on turf that favors the enemy and is intended to help warfighters orient rapidly, become pro-active earlier, and dominate adversaries with increasing effectiveness.

Unlike large-scale mechanized formations in the industrial age, today's adversaries try to hide by disappearing into complex environments. OA includes the ability to understand "human terrain" – to distinguish between adversarial/non-adversarial populations. Affordable, scalable, persistent surveillance is vital to OA. Our forces have capability gaps in maintaining surveillance over large areas with the persistence and resolution needed to identify threat activity and provide timely indications and warnings. These gaps are caused by limits of current sensor technologies, and by manpower requirements associated with operating individual systems and data interpretation. Several ONR projects are directed towards overcoming these limitations.

Utilization of improved sensors necessitates understanding the resulting data. Where mechanized warfare required understanding the physical characteristics of weapons platforms and their employment, hybrid warfare requires that we understand human phenomena as well. ONR utilizes the social sciences to investigate solutions to problems in human, social, cultural and behavioral arenas. These solutions will help better understand "human terrain" phenomenology, apply that phenomenology in operational contexts, and design or modify technologies that will enable us to make better use of affordable, persistent surveillance products.

ONR is currently conducting an Integrated Technology Demonstration to address operational gaps that preclude adequate warning of non-conventional hostile activities through affordable, autonomous, persistent, pervasive littoral surveillance. Success metrics associated with this demonstration include achieving sufficient advanced warning of hostile intent and actions to enable our forces to respond at the time and place of our choosing – rather than awaiting an enemy attack and then reacting to it.

Improvised Explosive Devices (IEDs)

As we know all too well, IEDs represent a persistent challenge. Continuing our work with the Joint IED Defeat Organization (JIEDDO), ONR funds research efforts aimed at attacking IED networks and devices, and training our forces. Working with other agencies, ONR is investing in prediction efforts involving terrorist activity: bio-forensic profiling to trace place of origin, factory location, support networks, placement, and dynamic analysis of suicide bombing. These projects anticipate threats, and put us in a better position to respond to changing conditions.

Scientists at Columbia, Drexel, University of Miami, and others working in ONR's Automated Image Understanding (AIU) program have developed computational methods and algorithms for recognizing hundreds of object categories, including tracking and analysis of human behavior. The intent is to develop automated identification of people and behavior to highlight potentially threatening situations. AIU is a critical capability for many Department of Defense (DoD) missions including, situational awareness, persistent and adaptive surveillance, and autonomous operations.

Near-term initiatives include the Advanced Technology Development efforts to neutralize IEDs through improved countermeasures as well as locating and directly attacking the device. Long-term S&T includes bio-inspired sensing systems (for example, technologies with the capability to mimic a dog's or an insect's ability to smell) for detection/tracking of explosive components in ports, coastal, and ocean environments. Advances in countering IEDs are compatible with Countermine Warfare in any environment. Efforts are underway to develop novel man/machine interfaces with the ultimate goal of developing unmanned, autonomous systems that separate warfighters from hazardous missions, while providing increased economy of force – an emphasis on autonomy and the development of unmanned systems technologies embedded throughout the S&T portfolio in order to more effectively meet emerging operational requirements.

Expeditionary Energy Requirements

Operations in Afghanistan have forced the Marine Corps to reevaluate energy distribution and use in expeditionary environments. Future challenges will likely require Marines to operate over long distances in austere environments, and we are actively pursuing a wide range of solutions. These include lessening energy consumption and dependence on fossil fuels, while achieving resource self-sufficiency. USMC requirements for energy span the full range of power levels, from watts to kilowatts to megawatts. S&T efforts are focused on energy requirements of individual Marines, small dispersed units, and the tactical vehicle fleet. Investments in battery technologies, 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 have significantly reduced energy consumption and usage in expeditionary environments.

Mobile, Modular Command and Control for Marines in Afghanistan

An example of ONR's Quick Reaction S&T was our response to a request early in FY 2010. Marines in Afghanistan were seeking a lightweight, interoperable, modular, reconfigurable, rapidly deployable, minimal setup/footprint Command, Control, Communications (C3) package for early entry expeditionary forces at the brigade and battalion level. ONR delivered a first prototype of the Mobile, Modular Command and Control System (M2C2), a C3 package integrating "First In" expeditionary or distributed forces with afloat forces - thereby providing Over-The-Horizon, Satellite Communications (SATCOM) On-The-Move, and a full tactical C3 picture. The initial operational prototype was delivered to Regimental Combat Team-7, which just returned from a demanding 20 day mission to report the M2C2 system operated flawlessly.

Medical Research related to IEDs and Hearing Loss Prevention

ONR continues work with the medical community to better understand the effects of IEDs and develop tools to connect event and medical data. Force Health Protection Advanced Technology Development efforts include modeling human responses to blast, ballistic, and blunt trauma, as well as modeling physical and cognitive effects of blast exposure and conditions arising from traumatic brain injury.

Another area of emphasis is reducing hearing loss and tinnitus experienced by personnel in high noise environments. We are working with medical and acquisition communities exploring multiple approaches to understand the physics of noise, reduce noise, attenuate noise that still exists, monitor and assess exposure, develop advanced personal protective equipment, and develop enhanced warnings and procedures to ensure noise exposure does not become damaging. A suite of technologies developed under the FNC program are now transitioning to the warfighter as part of the acquisition sponsor's Flight Deck Cranial program of record. We are working on treatment, including ground-breaking pharmaceutical interventions for situations where potentially damaging exposure does occur.

Naval Undersea Medical Research

Undersea Medical Research is a National Naval Responsibility. ONR investments: 1) further understanding of health threats to undersea warfighters, 2) develop novel mitigation strategies for decompression sickness, arterial gas embolism, and oxygen toxicity for disabled submariners and divers, and 3) assess other health challenges associated with undersea deployment. Products from our Undersea Medicine Program, such as development of non-recompression strategies for the mitigation of decompression illnesses, the elucidation of biological mechanisms that govern oxygen toxicity, and understanding the epidemiological consequences of undersea deployment will improve efficiency, flexibility, and safety of manned undersea operations.

Ship Survivability and Self Defense

In FY 2011, the Maritime Weapons of Mass Destruction (WMD) Detection program is moving toward more complex demonstrations of Special Nuclear Material detection technologies. These tests will be conducted in representative, Navy unique maritime environments which include over water and under-water applications.

As previously mentioned, the Free Electron Laser (FEL) INP is designed to defend against current and future surface and air threats, anti-ship cruise missiles, swarms of small boats, and other asymmetric threats. The FEL will provide new capabilities to sense, detect, and scale lethal effects to defeat multiple, rapidly maneuvering targets while reducing the cost of missile-on-missile engagement, deepening magazines, and providing complimentary depth of fire.

Power Projection

Also discussed previously, the Electromagnetic Rail Gun (EMRG) INP will provide multi-mission capability for long range, persistent, precision fire without unexploded ordnance issues, increased magazine capacity, and decreased cost. Projectiles will 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, the EMRG will provide opportunities for Anti-Surface Warfare and self defense.

The Long Range Anti-Ship Missile (LRASM) is a joint Navy/DARPA demonstration program that will significantly advance anti-ship missile technology by demonstrating survivability while penetrating advanced air defense networks – and achieve robust lethality through precision targeting. A LRASM flight test is expected in FY 2012.

Affordable Platforms

Technologies intended 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. This includes using operations research, modeling and simulation, and computer sciences to reduce costs and improve the caliber of training and skill maintenance technologies. 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.

Future Power and Energy Systems

ONR continues to invest in advanced technologies to boost platform electrical power for improved warfighter capability and to increase energy efficiency to enhance platform endurance and reduce the warfighter's 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 the Secretary's energy goals of sailing a Green Fleet in 2016 and increasing DoN energy consumption from alternative sources.

In concert with DoD and Navy Task Force Energy's focus on energy security and reducing the amount of fossil fuel use, we continue to invest in the Naval Future Fuels effort, investigating the impact of new fuel formulations on Naval machinery and helping accelerate the Navy's adoption of alternative fuels. Additionally, ONR is supporting the Navy's partnership with the Department of Agriculture through collaborative research on biofuels. In FY 2010, congress added $18.5 million for Alternative Energy Research. We are using this funding to continue the evaluation of energy positive structures, advanced solar and wind technologies, ocean energy technologies, and system integration impacts of intermittent, renewable alternative energy sources on power grids. Finally, ONR continues to support research in fuel cells, methane hydrates, and other alternative sources of energy.

Modular Open System Architecture

Modular and open system architecture enables the Navy to affordably procure, modernize and integrate complex systems. By assembling similar components to provide a range of cost/capability trade-offs, modular system architecture can be used across all classes of ships. Open architecture enables affordable upgrades for introducing new technical advances to respond to new threats.

An 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. The contract required the use of open interfaces and determined capability as a function of the number of receiver elements and channels. In addition, a third party provided components for some system elements. This allowed the PEO to not only use results of the S&T program for DDG 1000, but use underlying subsystems to develop the scaled back-fit for all ships in the Navy requiring EW-ES capability.

Similarly, the Affordable Common Radar Architecture program developed an architecture for all future radars in which the system is divided into frequency independent subsystems (radar control processor, human-machine interface, digital signal processor, digital beam-forming subsystems) which only need be developed once. They can then be used for all radars regardless of frequency and frequency dependent subsystems. The decomposition of radar into independent subsystems with open, well-defined interfaces enables Navy to procure the best components from any company and affordably upgrade only those elements which are necessary.

This experience led ONR to bring together a team of all major system integrators, along with key acquisition components, to develop Naval Radio Frequency (RF) modular system open 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 all ships with common RF hardware. This will reduce developmental acquisition, training and maintenance costs, and enable affordable upgrades due to open architecture.

This approach clearly involves acquisition challenges since various RF capabilities are currently funded by different Navy resource sponsors and acquired by different PEOs. In addition, the open subsystem construct may face Testing and Evaluation requirement challenges when only some subsystems are upgraded. I believe we can successfully address these challenges.

Information Dominance and Autonomy

The CNO has clearly signaled his intention of Navy taking the lead in information dominance. Since Naval forces must accomplish this without a growth in manpower, fundamental advances must be made in automated understanding of sensor and open source data, automated integration of highly diverse information, and the ability to automatically provide assessment and warning.

ONR S&T 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 that have been used by the National Geospatial Intelligence Agency, other intelligence organizations, and industry. Funds were also invested in advancing the science of understanding, manipulating, and integrating so-called "soft" data such as human intelligence and open source data.

ONR also initiated development of strategies and algorithms to automate of the integration of highly disparate data sets, including sensor and non-sensor data in order to understand the relationships between individuals, objects, and events in the battlespace which provides insight into the capabilities of threats. This is a big job. Humans are called on to do it today, but there is insufficient manpower to manage today's information sets, much less what would result from the large sensor and information networks required to provide comprehensive, actionable battlespace intelligence.

Even after the integration of large volumes of data, the task of actually assessing the implication of the results across a dynamic battlespace is formidable. This is also an area which requires extensive manpower. To automate this requires major advances in machine reasoning and intelligence. In consequence ONR has sponsored a series of workshops including 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 also forms the essential foundation that will enable large, diverse, mission-focused autonomous sensor and information networks for supporting rapid, accurate decision-making by commanders in the battlespace.

Marine Mammals and the Environment

ONR continues significant S&T investment dedicated to effective and responsible stewardship of the marine environment, including assessing the impact of national security activities on marine mammals. Navy is the worldwide leader in marine-mammal research, spending approximately $14 million annually to understand how marine mammals may be affected by sound. This figure represents a majority of funding for this research in the U.S., and nearly half spent worldwide, as Navy collaborates with universities, institutes, industry, conservation agencies, and independent researchers to better understand what combinations of ocean conditions and Naval activities could potentially impact marine mammals and the environment.

Understanding the Sea

Understanding the marine environment as a coupled system of atmosphere and ocean is critical for Naval operations including: Anti-Submarine Warfare, Mine Counter-Measures, and Naval Special Warfare. We work closely with Navy operational elements which make these forecasts. Our capabilities have steadily increased. Last year we added a novel hybrid coordinate ocean model. This year an important new variational assimilation approach to entering data into the models became operational with a significant increase in fidelity of the prediction. There remains much to learn about ocean processes, and our program has pursued a number of observational questions in the Western Pacific. A particularly important question is how the tides mix ocean water masses and create currents which affect the propagation of sound in the ocean and the abundance of marine ecosystems. Our goal is to capture the worldwide effect of tides in our prediction systems.

Highly capable research vessels are critical to the success of our basic and applied programs in ocean sciences. Since 1972, ONR has partnered with the National Science Foundation and other agencies in the University National Oceanographic Laboratory System (UNOLS) to allow joint scheduling and operations of a fleet of research ships used by academic oceanographers. The partnership continues with procurement of the next generation of Ocean Class research vessels. We are currently engaged in selecting from competitive proposals the two institutions that will receive these ships. There is keen interest in the selection and at the earliest possible time, Navy will let the committee know the result of this competitive process. Plans call for two ships to be built starting in FY 2011 and FY 2012, with lead ship delivery in FY 2014.

ONR Global

While we have tended to focus almost exclusively on the S&T process and programs, there is a worldwide dimension of S&T that we must address. This is because we have seen over 100 percent growth in global S&T investment over the last ten years.

In his book *Is America Falling off the Flat Earth?* Norm Augustine points out that among the top ten companies receiving U.S. patents in 2005, only four were actually U.S. companies. In recent rankings by the Organisation for Economic Co-operation and Development, the U.S. was 22nd in percent of GDP devoted to non-defense research. Up from 19 percent in 2004, China and India now account for 31 percent of the world's R&D workers. China has supplanted the U.S. as the world's leading high-tech exporter. In recent survey of 177 companies, 77 percent of new R&D sites planned over the next three years will be built in China and India, often with U.S. corporate financing. We must address, therefore, Navy awareness of—and access to—foreign S&T investments.

When Congress established the Naval Research Laboratory in 1916 and the Office of Naval Research in 1946 on the heels of World War I and World War II, the U.S. was arguably the world wide leader in S&T development and innovation. It is safe to say the U.S. monopoly no longer exists, making it imperative that we keep our finger on the pulse of S&T innovation in the international environment.

This is not new news; it is not even a new effort. ONR's London office, created to survey, assess, and report on European S&T activities was established coincidentally to the founding of ONR itself in 1946. ONR's office to similarly assess Asian S&T activities was opened in Tokyo in 1974. ONR subsequently opened a South America office in Santiago, Chile in 2004, a Southeast Asian office in Singapore in 2005, and most recently, a new office in Prague just last month. Our efforts are closely coordinated with the other services, the DoD Office of the Director, Defense Research and Engineering (DDR&E), and in full compliance with Section 211 of last year's National Defense Authorization Act.

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 consists of twenty Associate Directors in ONR Global offices who 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 strategic areas. This strengthens our ability to forecast both trends and threats in global S&T.

In FY 2008, International Science Program activities included our Visiting Scientist Program support for twenty visits to NRE facilities by scientists from 38 countries. Also in FY 2008, the Conference Support Program helped fund workshops at 117 conferences in 41 countries. And the Naval International Cooperative Opportunities Program supported 431 research projects in fifteen countries in which international scientists helped address Naval S&T challenges.

Conclusion

Thank you for the opportunity to discuss Naval S&T. The FY 2011 President's Budget request is about prevailing in today's threat environment and building a strong, flexible Naval force in the future. To achieve that goal, we continue moving toward greater integration of capabilities, more effective partnership between research and acquisition, and a clearer vision of how to achieve shared goals with DARPA, Army, Air Force, and other DoD research organizations.

S&T partnerships in 70 countries, 50 states, with 900 companies, 3,300 Principal Investigators, 3,000 grad students, and 1,000 academic and non-profit entities puts us in good stead to maintain our technological edge.

We continue to focus the majority 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. Nevertheless, we need to nurture the world class skills and innovation that exist within our lab system, especially at the Naval Research Laboratory (NRL). Congressional authorization to move ONR into the Lab Demo personnel system provides welcome assistance in our ceaseless effort to attract world-class scientists to become part of our organization.

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.

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HOUSE ARMED SERVICES COMMITTEE
UNITED STATES HOUSE OF REPRESENTATIVES

DEPARTMENT OF THE AIR FORCE

PRESENTATION TO THE HOUSE ARMED SERVICES COMMITTEE

SUBCOMMITTEE ON TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES

UNITED STATES HOUSE OF REPRESENTATIVES

March 23, 2010

SUBJECT: Fiscal Year 2011 Air Force Science and Technology

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

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INTRODUCTION

Ms. Chairwoman, Members of the Subcommittee, and Staff, I am pleased to have the opportunity to provide testimony on the Fiscal Year 2011 Air Force Science and Technology (S&T) Program.

The United States faces a variety of challenges to our national security and global interests. As an integral member of the Joint team, America's Air Force provides the critical capabilities of Global Vigilance, Global Reach, and Global Power. The current complex and uncertain security environment with which we're faced requires a balance-driven approach to prevail in today's operations and prepare for tomorrow's challenges by identifying and investing in new scientific research and technology development. This balanced approach postures the Air Force to provide an array of capabilities to Combatant Commanders across the spectrum of conflict — from building partnerships to ensuring the readiness of strategic deterrence forces.

AIR FORCE S&T FISCAL YEAR 2011 PRESIDENT'S BUDGET REQUEST

The Air Force Fiscal Year 2011 President's Budget Request for S&T is approximately $2.2 billion, which includes approximately $200 million supporting devolved programs consisting of High Energy Laser efforts and the University Research Initiative. These investments sustain a strong 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 $12 million, reflecting Air Force leadership's continued support for its S&T Program, even in today's fiscally constrained environment.

Balancing investments to prepare for a wide range of future contingencies is a challenge that involves maintaining military superiority against near-peers with traditional threats, while

addressing terrorists with unconventional weapons and tactics. The Air Force S&T Program continues to address this challenge by shifting investments among a broad portfolio to attain a balance between near-term capability support, sustainability of existing systems, operations requiring more efficient fuel usage, enhanced manufacturing capabilities, and revolutionary technologies that address far-term warfighting needs. The Air Force must continuously strive to effectively and efficiently allocate its S&T resources to provide the warfighter with superior air, space, and cyberspace capabilities and ensure the technological superiority that is a centerpiece of our Air Force heritage.

The Air Force shifted over $100 million of S&T resources from advanced technology development to basic and applied research. This shift supports the Administration's emphasis on scientific research and represents an increase to basic research of approximately eight percent. This increased emphasis on basic research will better support a long-term investment in the development of world class science, technology, engineering, and mathematics (STEM) capabilities for the Department of Defense and the Nation. The Air Force basic research program supports over 1,500 graduate students and 500 post-doctorates, as well as several student education outreach programs that will create the Science and Engineering (S&E) workforce of the future.

AIR FORCE S&T SUPPORTS AIR FORCE STRATEGIC PRIORITIES

The Air Force S&T Program 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

Further, these Strategic Priorities help shape S&T investments along with input from the Capabilities Review and Risk Assessment and a new planning process covering the Air Force core functions that is starting to emerge. The Air Force has established an S&T "tiger team" to capture this new strategic planning process in the Air Force's S&T strategic planning process with an emphasis on integration of advanced technologies to provide new capabilities for the warfighter. The new S&T process will be primarily focused on S&T demonstration efforts and may involve approval and prioritization at the corporate Air Force leadership level.

AIR FORCE S&T INVESTMENT IN FUTURE AIR FORCE CAPABILITIES

The Air Force S&T Program is the building block of the larger modernization enterprise, and is poised to discover, develop, and demonstrate technologies that are sufficiently mature to modernize legacy systems and transition into new system developments. The objective is to develop and demonstrate technologies that are delivered at the right maturity level, at the right insertion date, and with the right performance to meet the needs of the warfighter.

To achieve these S&T objectives requires a healthy and vibrant S&E workforce that can deliver joint warfighting capabilities to address the challenging security environments of the 21st century. The Air Force S&T Program is committed to developing and caring for over 3,100 S&Es. This commitment is reflected in the utilization of various flexibilities afforded the Air Force under the Laboratory Personnel Demonstration Project and other workforce development initiatives. Our Fiscal Year 2011 budget proposal enables us to recruit, develop, mentor, and retain the best and brightest scientists and engineers — a key priority within the S&T Program.

In addition, our scientist and engineer development teams continue to create new leadership development tools and initiatives to vector laboratory scientists and engineers into the appropriate career paths necessary to ensure future Air Force technical leaders for years to come. Workforce initiatives at the Air Force Research Laboratory are also proving successful in increasing mission effectiveness and improving the health and morale of laboratory personnel. These initiatives place great emphasis on the value of our people and maintaining the right mix of highly qualified scientists and engineers.

For the past three years, the Air Force has been leveraging this S&E workforce to re-invigorate systems engineering and development planning, and we continue to develop the tools necessary to assess the maturity of pre-program materiel concepts before they are selected as the preferred solution. The Air Force's Technology Readiness Assessment process has proved to be a highly beneficial tool to ensure a program's technology maturity. To further enhance these benefits, the Air Force is collaborating with the Office of the Secretary of Defense to develop a synergized independent program review and assessment process that integrates multiple technical reviews (e.g., technology, systems engineering, reliability, manufacturing, logistics, and risk) into a single Program Support Review.

In addition, the Air Force has matured a new rapid reaction S&T process to become more responsive to high-priority, near-term warfighter needs. The process involves a quick-look study team being formed to assess the need, conduct a root-cause analysis, and identify potential solutions. Concurrent with warfighter needs, or technology "pull" improvements, the S&T community anticipates capability needs, assesses technological trends, and develops emerging technologies that may "push" innovative or unanticipated capabilities to warfighters. As the pace, assortment, and availability of technological choices occurs more rapidly, the ability to develop and select the most advantageous technologies and transition them effectively and

efficiently has become essential to win today's wars, modernize aging systems, and develop and mature technologies that are available for transition into new system developments.

AIR FORCE S&T SUPPORT OF SERVICE CORE FUNCTIONS

The Air Force S&T Fiscal Year 2011 President's Budget Request supports the following Service core functional areas.

NUCLEAR DETERRENCE

The S&T Program plays a vital role in the continued strengthening of the nuclear enterprise through various investment programs, including nuclear detonation remediation activities, radiation-hardened electronics, threat warning systems, and the Technology for Sustainment of Strategic Systems program. Additionally, the S&E workforce provides extensive intellectual capital in this important area.

AIR SUPERIORITY

New and unprecedented challenges to our Nation's Air Superiority continue to emerge and threaten to remove the technological advantage enjoyed by our Air Force. The Air Force, with the Defense Advanced Research Projects Agency (DARPA), is developing technologies that will culminate in the demonstration of an Electric Laser on a Large Aircraft (ELLA) that is built around DARPA's High Energy Liquid Laser Area Defense System (HELLADS) laser device. After HELLADS development is complete, the Air Force will couple it to a beam control system for a series of ground demonstrations followed by integration of a system module into the forward bomb bay of a B-1B. ELLA will be used to demonstrate the aircraft self-defense capabilities of a high energy electric laser in a practical platform.

A new type of magnetron that may be used to defeat enemy electronics is the result of Air Force funded research and holds the potential for more compact microwave sources with faster

start-up, as well as higher peak and average power. Higher power magnetrons could be utilized to jam and defeat enemy electronics, while higher frequencies have the potential to improve radar resolution and the more compact packaging of the new magnetron may enable airborne applications. In addition, we continue to develop other robust electronic protection technologies and techniques to counter current and advanced electronic attack deception technologies. A countermeasure system with the proactive ability to scan, detect, track, and identify an enemy tracking system has also been demonstrated.

SPACE SUPERIORITY

America's ability to operate effectively across the spectrum of conflict rests heavily on our space capabilities. Developing technologies to assure responsive access to space and the use of space assets remains a top Air Force priority. We continue to develop and demonstrate liquid rocket technologies to support a future reusable booster system. We also continue to address the prevalent space situational awareness challenges presented by the need to be able to detect, track, and identify, as well as provide on-demand, highly detailed characterization of individual space objects and near-real-time, high-fidelity forecasts of space environmental effects.

The S&T Program has been instrumental in developing technologies for the Joint Space Operations Center (JSpOC), which allows space operators to perform space situational awareness activities to protect our use of space assets. JSpOC technologies under development will enable decision makers to rapidly understand activities, threats, conditions, and situations by exploiting information and synchronizing effects across air, space, and cyber domains to gain and maintain mission assurance through a global space situational awareness picture.

Last March, TacSat-3 was launched and we are collaborating with the U.S. Army and other partners to test and prove the capabilities of tactical-mode collection and processing, utilizing the

primary hyperspectral imaging payload. TacSat-3 was designed as the next step in smaller, lighter, lower cost satellites that would be more responsive to the warfighter in the field.

CYBER DOMAIN

Operating within the cyber domain has become an increasingly critical requirement for our networked force. The Air Force is firmly committed to developing the necessary technologies to defend the cyber domain and enable our forces to operate in cyberspace under a wide range of conditions, including contested and degraded environments. Our Fiscal Year 2011 budget request continues to emphasize research, as well as technology development and demonstration in this important Core Function to allow us to grow our cadre of cyber S&E experts to protect and defend information networks.

Our information technology architecture enables an entire universe of command and control and intelligence, surveillance, and reconnaissance (ISR) capabilities that underpin all aspects of Joint operations and are paramount to maintaining our technological superiority and mission assurance in every domain. The S&T Program continues to assist forces in Iraq, Afghanistan, and elsewhere with new and more effective means for rapidly processing, exploiting, and fusing information from a wide array of sources and disseminating this information to operators at the tactical level. Developing improved ways to share information with allied Air Forces is critical to success. We are developing the ability to share classified information across multiple computer networks operating at different security levels.

To be sure, cyber technologies enhance our ability to maintain unprecedented situational awareness at all levels of operations; however, our reliance on them has also created vulnerabilities that we must address and mitigate. We have recently transitioned multiple technologies developed under a Cyber Attack Mitigation Exploitation Laboratory to collaborative partners. Strategies and policies are continually under development to improve cyber defense, resiliency of networks, and

surety of data and communication, so that we will continue to have confidence in cyberspace operations.

GLOBAL PRECISION ATTACK

Enhanced long-range strike capabilities are one means of ensuring our power projection capabilities, thereby, countering growing threats to our forward-deployed forces and bases. Building on insights developed during the Quadrennial Defense Review, the Secretary of Defense has ordered a follow-on study to determine what combination of joint persistent surveillance, electronic warfare, and precision-attack capabilities, including both penetrating platforms and stand off weapons, will best support United States power projection operations over the next two to three decades. Findings from that study will inform decisions that shape the Fiscal Year 2012-17 S&T Program. We are already conducting a comprehensive reassessment in the conventional weapons arena looking at gaps, material solutions, and technology needs across the breadth of operational capabilities to include air superiority, close controlled strike, intra-theater strike, and long-range strike.

The X-51 Scramjet Engine Demonstration project will provide hypersonic propulsion technologies needed for an affordable, fast reaction, stand off weapon or access to space vehicle. The X-51's first flight is planned for this year and will allow us to correlate flight test data with ground test data and modeling and simulation analyses. In support of hypersonic and space access technologies, we continue to emphasize high temperature materials' development and thermal management research. Directed Energy and micro-munitions' technologies will deliver precision effects and will provide warfighters the ability to engage high-value fleeting targets in an urban environment with low-collateral damage. Our development of airborne high-powered microwave systems, capable of knocking out adversary computer and communication networks, is an example of an extremely low-collateral damage, precision attack technology.

RAPID GLOBAL MOBILITY

Global Reach ensures our Joint team can deploy, maneuver, and sustain large forces on a global scale. In Iraq and Afghanistan, Air Force mobility assets are central to sustaining the Joint and Coalition team. On any given day, Air Force C-5s deliver life-saving Mine Resistant Ambush Protected vehicles into theater, C-17s airdrop critical supplies to forward-based ground forces, and C-130s provide tactical airlift to move theater-based personnel and equipment. To manage these diverse mission sets, we are developing and demonstrating technologies that can transition to hardware and software architectures for Air Mobility Command. These technologies can synchronize real-time events, such as route planning, refueling, projected time over country, and diplomatic clearance events. They also can decrease mission disruption, increase effective resource allocation decisions, and reduce airlift replan time.

We are developing novel technologies to assist in prolonging the life expectancy of our aircraft systems and we are also looking at ways to decrease the cost of sustaining these systems. Our strong commitment to composite aircraft structures, materials, and manufacturing techniques has led to potential ways to shorten the development time for the next generation cargo aircraft, as well as improve strength, weight, and mission utility over current legacy aircraft. For example, we replaced an aircraft metallic fuselage with a composite one, reduced weight, went from 3,000 metallic parts to 300 composite parts, and went from 40,000 fasteners to 4,000. We are developing advanced lift technologies to address special operations' need for a highly survivable transport for clandestine infiltration/exfiltration and mobility needs for a theater airlifter that can carry larger vehicles to forward locations.

SPECIAL OPERATIONS

One of the Air Force's five Strategic Priorities is to 'Partner with the Joint and Coalition Team to Win Today's Fight.' The Air Force S&T Program is supporting multiple joint initiatives to

get technologies to the Combatant Commanders faster to 'win today's fight,' including deployable force protection, ISR, lightening the warrior's load, and linguistic, regional, and cultural abilities. We continue to enhance technologies to conduct precise, timely, and effective missions across the full spectrum of special operations to include close air support and air interdiction.

Electrochemical hybrid power technologies have been used to extend the persistence of forward operating units. The Air Force S&T Program has developed and transitioned a fuel cell/battery hybrid power system to the United States Special Operations Command, which can extend the duration of small Remotely Piloted Aircraft (RPA) missions from two hours up to more than nine hours, enabling sustained observation of high valued targets and providing essential ISR information to protect Army, Navy, and Air Force Special Forces. Within the Air Force S&T Program we are also developing technologies to lighten the load and improve agility for Special Operations Forces who often carry up to 170 pounds of separate, non-integrated pieces of equipment for missions. Technologies from the Battlefield Air Operations kit, designed to reduce the load of equipment and increase the mission effectiveness, have led to a wearable information display management system and a hand-held Internet Protocol-capable radio, enhancing information management and decision making, streamlining displays, networking forces with RPAs, weapons, and tactical error, while reducing weight by 35 pounds.

GLOBAL INTEGRATED ISR

Long-dwell RPAs, such as the Predator, Reaper, and other systems, have proven to be invaluable for monitoring activities in contested areas, enhancing situational awareness, protecting our forces, and assisting in targeting enemy fighters. We are exploring ways to enhance the effectiveness of our fleet of ISR aircraft by developing innovative sensor technologies, efficient propulsion systems, support infrastructures, and operating concepts to include novel technologies to process, exploit, and disseminate multi-intelligence data. This year, we began evaluating a rapid response RPA package supporting force protection of Central Command forward operating bases.

The RPA package contains a day/night multi-spectral imaging sensor and a fully autonomous operating capability for launch and recovery, particularly useful in route clearance operations.

Globally integrating our ISR capabilities requires an increased focus on joint collaborations, which we continue to emphasize. Our Global ISR activities also involve investigating methods to integrate multi-sensor biometrics with dynamic human modeling to find, fix, track, and identify human subjects anywhere, at any time. Significant progress has been made on continuous, real-time, 24/7 situational awareness in all weather for tracking, fingerprinting, and identification of vehicles in an urban environment, as well as the continuous tracking of dismounts. Combining our progress in global air, space, and cyber ISR technologies and precision weapons, we are integrating tracking into the equation — both forward tracking and the ability for the warfighter to track backwards and perform forensic analysis on any event. We continue to emphasize persistent sensing technologies through a layered and flexible sensing architecture, and on developing new research to detect and track moving targets on the ground. One jointly funded effort will integrate ground moving target indicator technology onto the Joint Improvised Explosive Device Defeat Organization-funded Blue Devil system scheduled for deployment to Afghanistan in summer 2010. This system will detect and track vehicles, and later dismounted personnel, over a wide area.

COMMAND AND CONTROL

The growing sophistication of electronic warfare methods and techniques dictates that we improve the protection of our communications and data links from degradation and even denial. Many command and control operations rely on space assets to include the ground station infrastructure. We recently demonstrated an advance antenna technology to support the Air Force Satellite Control Network that has an average effective capacity equivalent to four similar size dish antennas with practically no maintenance down time. In support of Special Operations Forces, we recently transitioned an X-band satellite communications terminal that is a lightweight backpack unit, providing global reach to the tactical edge warfighter.

In addition, we are investigating wide bandwidth, multi-user space communication options that include lasers, advanced radio frequency, and reconfigurable communication technologies. Laser communications are not subject to spectrum allocation issues and will provide a capability that is robust against jamming and interception. In the RPA arena, we are exploring concepts for long-haul communications relay systems, allowing simultaneous, cooperative command and control of multiple RPAs. With the growing RPA population, we have been working with the Federal Aviation Administration to develop technologies to operate our systems safely in a demanding airspace through autonomous detection and avoidance of neighboring aircraft.

PERSONNEL RECOVERY

Personnel Recovery remains an imperative, fulfilling our promise to never leave an American behind. Highly skilled aeromedical transport teams swiftly evacuate combat casualties, ensuring our wounded warriors receive the best possible medical care. The S&T Program recently completed the development of a portable electronic power supply to address the problem of heavy and cumbersome power converters used to power medical equipment on aircraft. We reduced the weight and size of a previous 80-pound, aircraft-tethered unit into a small, lightweight, portable, 34-pound unit. The new unit also has zero emissions, fewer cables, and power independent of the aircraft, allowing the unit to travel wherever the patient goes.

BUILDING PARTNERSHIPS

The Air Force continues to seek opportunities to develop our partnerships around the world, and to enhance our long-term capabilities through security cooperation. The Air Force S&T community is very active in building partnerships with our coalition allies. We established a partnering agreement with the German Ministry of Defense in the area of conventional munitions to investigate high explosive sensitivities under high shock conditions, such as those induced as weapons penetrate hard targets. We are collaborating with Australian researchers in conducting

leading-edge research in next generation over-the-horizon radar and hypersonics, and the final demonstration of a six-year agreement with the United Kingdom on high cycle fatigue in our turbine engines is scheduled for this year. New tools and technologies from this program have nearly eliminated Class A mishaps attributed to high cycle fatigue. With these safety and other technologies being applied to all future turbine engines, total propulsion maintenance costs could be reduced by 50 percent.

We continue to adapt existing language programs and policies to develop the intellectual capital necessary to meet the challenges of operating in a changing and complex environment. We are looking at the foundational elements associated with computational and modeling approaches to study behavior of groups and communities with an eye towards understanding the interactions between demographic groups — both to support technology developments for enhanced cooperation, such as operational decision making with coalition partners, and to explain and predict outcomes between competing factions within geographic regions. The goal of our research and technology development is to improve the Air Force's operations with our joint and coalition partners, and better understand enemy intentions and objectives.

AGILE COMBAT SUPPORT

Underpinning all Air Force Core Functions are the capabilities and technologies included in Agile Combat Support – these efforts affect the entire Air Force cutting across activities to include energy, manufacturing capabilities, and our industrial base, as well as the previously discussed development and training of our Airmen and the revitalization of our processes in the acquisition enterprise. In addition, it includes our focus on sustaining legacy capabilities during these times of austere budgets and fewer new system developments.

Petroleum usage continues to be an area of great concern given the Air Force is the United States Government's largest consumer of petroleum, leaving us the most susceptible to energy price volatility and disruption of logistics lines. In order to reduce its reliance on oil, the Air Force will

continue to field innovative technologies to provide energy to its bases, reduce its logistical footprint and energy-intensive base infrastructure in the continental United States and elsewhere, and invest in S&T on transformative propulsion systems for future energy efficient platforms.

The Air Force is aggressively addressing both the supply and demand components of energy. Alternative fuels lie at the intersection of efforts to improve fuel supply security, reduce dependency on foreign fuel purchases, and reduce the environmental impact of Air Force operations. The Air Force has had notable successes in evaluating and certifying alternative aviation fuels from biomass, coal, and natural gas for use in aircraft turbine engines. Biomass-derived fuels are the current focus of Air Force test, evaluation, and certification activities for both legacy and advanced engines.

To reduce energy demand, the Air Force and industry are investing considerable S&T resources to develop and demonstrate technologies for turbine engines that can automatically adjust for optimal performance and fuel efficiency at all flight conditions. Benefits of increased fuel efficiency also benefits performance, including increased range, loiter time, and speeds. These technologies have pervasive system benefits that will enable transition to a wide range of future platforms with greater mission endurance requiring fewer operational aircraft and a reduced logistics footprint in the theater.

The Air Force Manufacturing Technology (ManTech) program has a long record of achievements in addressing pervasive industrial base needs where affordability, technology maturity, and manufacturing readiness are the main concerns. ManTech's mission is to create an affordable, world-class industrial base manufacturing capability responsive to the warfighter's needs. Towards this end, ManTech develops, demonstrates, and transitions advanced manufacturing processes and technologies to reduce costs, improve quality/capability, and shorten cycle times of weapon systems during design, development, production, and sustainment. ManTech objectives are conducted through partnership with laboratory,

acquisition, and sustainment programs working through all industry levels from large prime contractors to small businesses. This way, appropriate strategic issues and emerging innovative manufacturing technologies and transformational opportunities are identified that bring about dramatic improvement to Air Force industrial base capabilities. Based on this process, examples of current ManTech programs include affordable Active Electronically Scanned Array radar for airborne platforms, advanced ceramics for fuel efficient turbine engines, out-of-autoclave advanced polymeric composites for structures, affordable space solar cells, affordable microelectromechanical components for tactical missiles, rapid prototyping for RPAs, high velocity maintenance, and advanced precision robotics for various assembly operations. These Air Force ManTech investments help ensure manufacturing advancements are in place to enable affordable, producible Air Force systems now and into the future.

CONCLUSION

The mission of the United States Air Force is to — fly, fight, and win…in air, space and cyberspace — as an integral member of the Joint team that ensures our Nation's freedom and security. Guided by the Air Force Strategic Priorities and our service core functions, our S&T Program provides the balance necessary to ensure support of today's warfighter, while posturing for success against tomorrow's complex and uncertain future. Innovation is a competency that we must continue to nurture as a potent mechanism against uncertainty — and, it can only be realized by nurturing a strong, robust and well-educated S&E workforce. The Air Force continues to show a strong commitment to its S&E workforce through a myriad of STEM outreach programs and initiatives and also continues to show a strong commitment to its S&T Program. This commitment is clearly shown through the Air Force Fiscal Year 2011 President's Budget request of $2.2 billion for S&T efforts.

With this commitment of people and resources, the Air Force S&T Program will continue to be a trusted and reliable joint partner with our sister Services and Agencies, known for integrity in all of our activities to include supporting the joint mission first and foremost. The S&T Program will provide compelling air, space, and cyber technologies, ensuring capabilities for use by the Combatant Commanders, while providing innovative technologies to support Global Vigilance, Reach and Power for the Nation.

Ms. Chairwoman, thank you again for the opportunity to present testimony and thank you for your continuing support of the Air Force S&T Program.

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Statement by

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Submitted to the

Subcommittee on Terrorism, Unconventional Threats and Capabilities
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On July 19, just prior to starting as the Director, one of the previous DARPA directors counseled me. He said, "DARPA is one of the gems of the Nation. Take care of her."

Which is really an elegant way of saying, Regina, this is important, don't screw it up.

Madam Chairwoman and Members of the Subcommittee... My name is Regina Dugan, I am the Director of the Defense Advanced Research Projects Agency. I am proud to be here. And I am clear about the weight of my responsibility. I share this responsibility with an outstanding Deputy, 7 capable office directors and their deputies, dedicated military liaisons, 101 spirited program managers who are the soul of the Agency, and a comparable number of support staff who embrace a "we'll find a way" work ethic. Our responsibility is to our warfighters and to the technological superiority of the Nation's defense. Frequently, the resulting innovations also contribute significantly to the Nation's economic vitality. We challenge existing perspectives, break china, and make people excited and uncomfortable, sometimes with the same sentence. You might say that DARPA is the Nation's elite army of futuristic technogeeks. And this is our service to country.

I am also clear that there is a fine line between pride and self-congratulation. As you are well aware, over the 50 years of its existence, this Agency has achievements ranging from the Internet to stealth, from GPS satellites to MEMS technology, from rockets to the M-16 rifle. We like to refer to these accomplishments. Often. We all feel proud of that rich history. Indeed, this spectrum of accomplishments, over half a century, is so impressive that many have sought to emulate the DARPA brand. And we have, ourselves, sought to understand the underlying elements responsible for this long string of successes. We discussed the essential elements of this success at the January 7 meeting of the President's Council of Advisors on Science and Technology. Namely:

- A commitment to working at the intersection of basic science and application.
- The steadiness in funding that results from the Government's responsibility to provide for the Nation's defense, and our role in so doing.
- The focus, urgency, and breadth of solutions required to serve Defense needs in austere, life-and-death situations.

These essential elements call for our best and brightest. For boldness. And they focus the mind. They give rise to DARPA.

But, I want to be straight. Understanding the instrument is primarily a means for ensuring we well use and protect it. You should expect this of me and of the Agency. I get that. And I agree. Further, articulating past successes is a confidence builder both for us and for you. It suggests that the Agency should be afforded some flexibility. Because the future impact of bold new ideas often cannot yet be understood, and capitalizing on advances often requires changes on short timescales. But we should avoid the error of self-congratulation. It is indulgent. The spectrum of challenges we face now and into the future is vast. The challenges are too big to do it alone. And we've got too much to do to rest on past successes or an outstanding reputation.

In support of our budget request, today I will talk about our contributions to the current fight; these contributions are measured in efforts over months and in investments over years. I'll turn to our ongoing programs because these are the seeds that promise to impact next-generation capabilities. And we'll talk about what's next by describing novel initiatives that challenge our conventional thinking and address some of the most complex problems of our time.

We recognize that we cannot achieve great things alone, and so I will also address our efforts to engage the best talent in the country from universities to industry (small and large) as well as our partnership with the Services. It is said that "Ambition is a dream with a V8 engine."
So, I'll conclude by highlighting our recent efforts to fine-tune the engine. Because execution is what turns dreams into reality, the Agency must operate with agility, speed, technical and administrative integrity. It's the horsepower that allows us to make that which we imagine... real. Today and into the future.

Let's start with the current fight. It's on our minds.

We are supporting operations in the current fight. I have just returned from Afghanistan and it is clear that there is no shortage of challenges. This is an insurgency; IEDs are the weapon of choice. It is a coalition fight; and we seek transfer of responsibilities to the Afghans. Technology plays a role across this spectrum and DARPA contributes through both short-term responses and the realization of efforts started years ago. Two recent efforts, HALTT and Crosshairs, are directed at the challenge of protecting helicopters and ground vehicles in

theater. We dramatically accelerated the fielding of these technologies in close collaboration with DDR&E and the Services.

The Helicopter Alert and Threat Termination (or HALTT) program addresses the need for hostile fire indication of incoming small arms fire, which account for 85 percent of hostile fire engagements. HALTT uses advanced acoustic detection and data processing to exploit the supersonic shock wave produced by a bullet in flight. The system alerts the crew to an attack and provides shooter location with "o'clock" accuracy. A prototype HALTT system has been installed on an Army UH-60 L Blackhawk helicopter, which underwent air worthiness and performance testing just last month. Soon, we will deploy several systems to Afghanistan for operational evaluation. From funding allocation to live fire test completion, this effort took an unprecedented 5 months and will be fielded in less than a year from identification of the need.

Similarly, the DARPA Crosshairs program will develop and validate technologies to protect ground vehicles in Iraq and Afghanistan from small arms, rocket-propelled grenades (RPGs), and other advanced threats. Crosshairs detects, classifies, and backtracks threats. It will geolocate and display shooter position on an interactive map and then slew-to-cue an overhead weapon based on user inputs.

Both HALTT and Crosshairs promise to make it very dangerous to shoot at US Forces. Because the first shot may very well be the adversary's last.

Some assume that the nature of preventing or creating strategic surprise suggests that we cannot contribute on the timelines required to support current operations. Not true. HALTT and Crosshairs illustrate that we can help. At any point in time, DARPA has technologies in all stages of development: from nascent idea to system ready for fielding. Second, I do not believe that strategic surprise observes predetermined timelines. Indeed, strategic surprise can occur on any timescale. We get a vote. And so does the adversary.

The evidence of these basic tenets is in the Agency's history. DARPA has been involved in support to active conflicts since the Vietnam War. When the country is at war, and we can contribute, we are obligated to do so. It is our duty. Defense systems must work. Period. Not only in the most benign environments, but also in the most austere... on the sea, in the mountains, in jungles, with sand, dust, or water. Anytime, day or night. Under life and death

conditions. I believe that this breadth, urgency, and technical demand must be real to focus the mind. This authenticity inspires greater genius. And it cannot be created in the abstract.

We continue to be committed to contributing, where able, to the current fight. My trip to Afghanistan reinforced this commitment and suggested a number of potential options that we are investigating. Not surprisingly, DARPA's work is unusual in texture and character. Less about response to already articulated needs than observations of opportunities not yet conceived, these efforts are nevertheless well-aligned with other, often heroic efforts, within DDR&E and various rapid response programs within the Department.

We must balance this investment with our responsibilities to the next generation of warfighters. The importance of striking this balance can be seen in the current theater of operations, because many of the technologies in use in today's fight were once DARPA programs.

There was a time, not long ago, when it was considered inconceivable (or at least ill advised) to fly an aircraft without a pilot onboard, let alone that there could be a system that fulfilled the entire kill chain – from finding and fixing, through tracking and targeting, to engaging and assessing.

Today, in all likelihood, a small patrol of Marines in the Helmand province is faced with dangerous uncertainty about what lies just beyond their limited, earthbound line-of-sight. The complex environment in which they must operate provides ample concealment for potential adversaries. Today, that patrol has options. They may choose not to accept the risk inherent in moving blindly around the next corner, behind the tree line, or over the ridge. They might choose instead to launch a tiny airplane called WASP, which gives them a birds-eye view. WASP allows them to see what was previously unseeable. Equipped with "binoculars in the sky," the patrol may be able to avoid a potential ambush site and, instead, surprise the enemy.

Elsewhere in Afghanistan, a commander receives critical information concerning the movement of enemy forces staging for an attack. The information comes in the form of high-definition full-motion video giving him both the detail and the critical time necessary to make a sound decision. Unseen and unheard, the silent sentinel is directed to train an unblinking eye on the enemy combatants and track their every move while friendly forces prepare a response. The

silent sky sentinel we now all know as Predator prepares US and coalition forces and then records the results of a successful engagement.

The UAV capabilities deployed on the battlefield today started in DARPA in 1984 with Project Amber, the original goal of which was to create a long-endurance, low-observable UAV with sophisticated sensors for photographic reconnaissance and electronic intelligence missions. From the small WASP to the Predator to Global Hawk, these systems now number hundreds in Afghanistan and Iraq. What once seemed impossible has become routine. In the very near future, the United States Air Force will train more UAV pilots than conventional pilots, and today we talk about "blackening" the sky with such systems.

This progression characterizes many of DARPA's advances: first impossible, then improbable, eventually inevitable.

The Autonomous Real-time Ground Ubiquitous Surveillance - Imaging System, or ARGUS-IS, is a next-generation airborne capability, providing wide-area, high resolution, color video imaging that enables persistent surveillance of dynamic battle spaces and urban environments.

The system consists of three elements: A 1.8 billion pixel video sensor that runs at video frame rates to support tracking of both ground vehicles and dismounted targets. When videos representative of Constant Hawk and Argus-IS capability are compared side by side, the benefit is clear; even amateurs can more quickly and unambiguously identify dismounts. And the easing of this analysis task for humans is mirrored in the easing of the analysis task for the computer. The reliability of automatic tracking algorithms improves, thus enabling a first step toward relieving the pressure felt by the data volume.

The USAF and DARPA will be conducting a final series of test flights this summer as part of the transition of ARGUS-IS to the Wide Area Airborne Surveillance (WAAS) program. ARGUS-IS is currently being evaluated for readiness for inclusion in funded Quick Reaction Capability (QRC) programs.

The Integrated Sensor Is Structure (or ISIS) program is advancing theater-wide surveillance, tracking, fire control, and engagement through the technology development, integration, and flight demonstration of extremely large, lightweight radars embedded in the structure of station-

keeping stratospheric airships. The size of a 15-story apartment building and operating on multiple frequencies, these large unmanned airships promise to provide extremely long-range continuous surveillance, individual target tracking, and engagement guidance for all air and ground targets, to include extremely small cruise missiles and UAVs, insurgents and guerilla forces, and small vehicles operating under foliage – capabilities not possible using existing or planned air or space assets.

The range of potential applications is wide, from maritime surveillance to ballistic missile and homeland defense. Logistically resembling a satellite, such a fully-regenerative solar-powered airship may be able to provide decade-plus operation at significantly reduced costs compared to present systems. If successful, a single station-keeping ISIS near Karbala in 2000 would have afforded coverage of the No-Fly Zone in Iraq at less than 5 percent of the $1.4 billion Southern Zone operation and sustainment.

So, our charge is two-fold: When possible, provide solutions in support of current operations, and invest in next generation capabilities. The Agency's future investment is broad, ranging from hypersonic vehicle technologies to vaccine production using tobacco plants.

The Falcon program is in the final stages of preparing for the first U.S. flight test of a long-range hypersonic, boost-glide vehicle. During this past year, the program successfully completed the assembly, integration, and ground testing of the first flight vehicle as well as planning and preparations for the first flight test. The system will be launched on a Minotaur-IV and, following release from the booster, is intended to fly approximately 3,000 nmi within the atmosphere to a terminal impact point north of the Kwajalein Atoll.

The program seeks to demonstrate unprecedented maneuverability, atmospheric flight time at hypersonic velocities, and critical capabilities supporting prompt global reach. It represents the seminal flight demonstration for the OSD Defense-Wide Conventional Prompt Global Strike initiative and is the foundation of planning to meet the US Strategic Command's Precision Global Strike requirement. It is a pathfinder program for the USAF Conventional Strike Missile Program and is expected to transition core technologies to other efforts within the Services.

Speed matters not only in global strike, but also in our response to a biological attack. Whether the attack is engineered or a naturally occurring pandemic, the Accelerated Manufacturing of Pharmaceuticals (AMP) program at DARPA utilizes recent advances in genetics, gene-transfer techniques, and specialized plant strains in sterile, automated facilities to demonstrate a radically different approach to the pharmaceutical manufacturing of flu vaccines. Such an approach would permit production ramp-up or redirection in response to a viral resortment in 30 days rather than 3 to 6 months and is independent of conventional egg-based, capital intensive, vaccine manufacturing approaches currently in use.

The potential success of AMP rests on previous advances made at DARPA. In March 2009, a Navy medical team received information on an (unknown) strain of influenza. Using previously developed DARPA technology, the team identified the strain as being H1N1. The DNA sequence was identified and transmitted electronically to the DARPA AMP facility. A "live fire" test was performed and protein (vaccine in its raw form) was produced from plants in less than 4 weeks. This rapid response was made possible because plant synthesis of the protein only requires the sequence and not the actual virus. The plants act as highly efficient drug factories producing the subunit protein (vaccine) which is then purified using established techniques.

We are pursuing two, complementary paths to establish this capability for rapid, responsive vaccine production. First, a small pilot facility will produce a vaccine-grade recombinant protein for formulation, immunogenicity, and toxicology studies. Data from those studies should lead to the filing of an investigational new drug package and clinical trials, the results of which are needed to consider potential approval of this vaccine under an emergency use authorization. Second, we will seek to demonstrate scale-up of the plant-based platform to 10 million doses per month. Together, these efforts could give the Department and the Nation an agile and flexible capability to neutralize natural or intentional pandemic disease. And, in cooperation with partners in other Agencies, DARPA's umbrella program, called Blue Angel, promises to provide the elements necessary to significantly thwart the biological terror threat.

It doesn't stop at systems we can see... the work at DARPA also encompasses nanoscale systems and those that exploit quantum mechanical effects…

Thin films of graphene are carbon nanotubes unrolled. They are single-atom sheets of carbon, one-third of a nanometer thick, that were used in devices as part of DARPA's nanotechnology

efforts. A nanometer is 1 billionth of a meter or 1 million times smaller than a grain of salt; it is the distance your nails grow in 1 second. These thin films promise to break through the 50-year-old limitations of traditional silicon microelectronic devices. Recent advances in carbon-based electronics would enable devices that have 10-fold higher operating frequencies and 100-fold lower power over silicon-based electronics. Imagine wireless devices that transmit HD video as effortlessly as voice and extend the operating time of our laptops and mobile phones from hours to days. In Defense applications, this means radar systems with 10-15 times the current range. Imagine being able to probe enemy assets at distances that put our platforms and warfighters well outside the reach of adversary systems and weapons. Interrogation or release of a weapon system is possible before the adversary can employ countermeasures. It's like having a really good right hook at the end of a 50-foot arm.

And because the intersection of basic science and practical application characterizes almost all that DARPA does, we pay careful attention to implementation. As we often articulate, advances in science are necessary, but insufficient. Our interest is in realizing the promise in such advances to create new capabilities. Advances in nanotechnology or nanomaterials have often resisted practical implementation in systems. This is in part because they are difficult to manufacture. As an example, we all know that production of silicon microelectronics is capital intensive. Investment in new manufacturing facilities can require billions of dollars. It's a big risk and a big barrier to overcome. So what's different about these recent advances at DARPA? These thin film layers of graphene can be directly incorporated into existing microelectronic fabrication methods, leveraging the decades, and the billions of dollars of investments, in silicon microelectronics manufacturing facilities.

The Quantum Effects in Biological Environments (QuBE) program poses a quintessential DARPAesque-style challenge. Namely, that biological sensors are not governed by "classical" physics at all. That this conventional world view is wrong. Rather, that quantum effects are necessary to explain the exquisite performance of biological sensors, which display high sensitivity, selectivity, and low false alarm rates, yet operate in dirty, noisy natural environments. Recent evidence suggests that the exploitation of manifestly quantum mechanical (or subatomic) effects would allow us to unlock the mysteries of a bird's magnetic field sensing used for navigation, the canine's keen sense of smell, and the highly efficient energy transfer properties of photosynthesis in plants. To date, we have failed to produce synthetic sensors

that mimic biological capabilities. Perhaps there is a whole new world of sensing on the other side of this question.

Sometimes it's not about what we can see, but what we can touch and feel.

Perhaps one of the most publicly recognized programs at DARPA is our 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, provide an arm that permits the same sensory experiences as a native limb. Currently, a neurally-controlled arm is undergoing qualification for its ability to restore tactile feedback to the user in a way that feels natural. Eventually, we envision an arm that will also allow the user to 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 had the privilege of meeting Fred Downs when he visited DARPA to demonstrate his use of one of the new arms. Fred lost an arm in the Vietnam War and has 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 advanced prosthetics program is part of a collection of programs at DARPA devoted to the care of our Service men and women. We seek to develop capabilities that help to stop blood loss, diagnose and treat traumatic brain injury, and assess those at risk for suicide. Our commitment to them is one way that we honor their commitment to the Nation.

So, what's next?

One of the biggest challenges we face as a Nation is the decline in our ability to make things. Americans today consume more goods manufactured overseas than ever before …and yet they are less likely to be employed in manufacturing than at any time in the last 100 years. In the

early 1940s, the manufacturing industry employed nearly 32 percent of American workers. By 2000, the industry employed only 13 percent of American workers.

There is much debate and discussion about the reasons: increased productivity, a decline in our S&T talent, currency manipulation, and trade policies. It is a complicated issue. But I believe we have come to appreciate the truth in Jeffrey Immelt's letter to the GE shareholders in 2008. He challenged the 30-year notion that the United States can prosper by moving from a technology and manufacturing leader to a service leader. He went on to say that "*...our businesses, our government, and many local leaders [have] lost sight of what makes a nation great: a passion for innovation...To this end...the ability to innovate must be valued again. We must discover new technologies and develop a productive manufacturing base.*"

At DARPA, we have developed a short hand for this... we say, "to innovate, we must make."

What does it mean for our Nation's defense, specifically? Adam Smith famously warned that "*if any particular manufacture was necessary, indeed, for the defense of the society it might not always be prudent to depend upon our neighbors for the supply.*" From the U.S. Civil War to the Second World War, industry's criticality to national defense has been demonstrated time and again. In World War II, the manufacturing burden for the United States and its war-torn allies was carried by American factories. These factories mass produced the aircraft, ships, land combat vehicles, and other vital support equipment instrumental to the Allied victory.

Not only is it true that to innovate, we must make. It is also true that to protect, we must produce. The parallelism is profound.

The Deputy Director, Dr. Gabriel, and I both came to DARPA from organizations that made things. We both know, at a visceral level, how difficult it is to make new products. We asked ourselves the following question: What is the fundamental technical challenge in making new things? And we concluded: It is in the seams. The seams between each 'stage' of development... design, prototyping, early production runs, limited and large-scale manufacturing. Seams between stages require extensive rework and are the source of production delays, surprises and cost overruns.

So, what if we could erase the seams? What if, rather than trying to create increasingly sophisticated prototypes, we could undertake large scale manufacturing in quantities of one? What would this imply? And is there an existence proof?

There is, in fact. The existence proof comes from the semiconductor industry and, in particular, fabless semiconductor companies. All semiconductor companies produce prototypes of new products/chips in exactly the same foundries that are used for large-scale manufacturing. Vertically integrated companies produce prototypes and move to large-scale manufacturing in the same, captive fabrication processes and facilities. Fabless semiconductor companies not only produce prototypes and move to large-scale manufacturing in the same fabrication processes, but do so without the need to own the fabrication facility. The nature of semiconductor fabrication has enabled the emergence of a business model and rationale for semiconductor foundry companies--- companies that do not manufacture products of their own, but instead only provide large-scale manufacturing to serve as efficient makers of products, distributing the cost of expensive manufacturing facilities across thousands of semiconductor products designed by hundreds of fabless companies.

This change was enabled by the insights of Mead and Conway in 1979. Mead and Conway wrote design rules and component models that were independent of manufacturing processes. Admittedly, some initial compromise was necessary in performance. But the resulting scale of innovation made possible by the sheer numbers of designers yielded advances that far surpassed those initial compromises.

The semiconductor industry experienced a period of explosive growth when the design process was decoupled from the manufacturing process, when the means by which we produced became rapid, cost effective, and seamless. In the semiconductor industry, hundreds of designers became tens of thousands. And students could access manufacturing lines for prototype runs in weeks at costs of hundreds of dollars. In the IT industry, similarly, higher levels of programming abstraction associated with the move from assembly code to Fortran, and the advent of personal computing, erased seams and increased accessibility.

Importantly, such a model represents high value-added manufacturing – where innovation and unique capability (not cost of labor) is the competitive advantage. It is the ultimate prize coveted by industrial leaders across domestic and international manufacturing industrial bases.

Our current investment in manufacturing innovation at DARPA totals approximately $200 million per year, or $1 billion over the next 5 years. We are synthesizing and integrating these efforts so as to contribute alternative design and production methods for next-generation systems. DARPA seeks to create breakthroughs in manufacturing that enable new innovations much like the breakthrough of the Internet enabled massive innovations in the communication and IT industries.

Which brings me to my last point: Because this type of massive innovation – in essence the democratization of innovation – has both risks and opportunity.

And in a world that is hyper-connected, socially networked, and global, the risks and opportunities are more extreme.

We often talk about globalization as a world without boundaries. But if you speak with a sociologist for even a few minutes, they will tell you that as long as humans are involved, there are boundaries. There are boundaries between men and women, between people in and out of uniform, between socio-economic classes, religions... What is different in a globalized world is that those boundaries, or edges, no longer conform to geographic lines on a map. Our ability to define these edges, from a technological and a policy perspective, has not yet evolved. Nowhere is this felt more acutely as a threat than in the cyber world. Nowhere is this felt more acutely as an opportunity than in the global mindshare of democratized, crowd-sourced innovation.

Social networks are powerful. They are poised to transform our society. There are many examples of emergent, coordinated behavior in social networks, as in the contributions to Wikipedia or Trapster or North Korea Uncovered, as well as social networks used as tools to organize large groups of people with common interests, as in the 2008 US presidential campaigns and in the protests following the 2009 Iranian presidential election.

Trapster. Trapster is an application for getting speed trap alerts on your Blackberry, iPhone, Nokia, Android, Windows Mobile, Palm Pre, Garmin, or TomTom device. The application crowd-sources the identification of speed traps. Smartphone users identify and map speed traps in real time on their phones. The application averages 6,000 new traps reported every day. In

order to ensure the reports are accurate, Trapster's "Trapologists" constantly monitor the trapmap and evaluate each trap. Recently, local police departments have also gotten involved. The Travis County Sheriff's Office in Austin, Texas, is now entering its own enforcement locations, as well as other information such as dangerous intersections, road closures, accidents, and traffic jams. Trapster gets drivers to slow down – which is, ultimately, the goal.

North Korea Uncovered. On Google Earth there is an image of North Korea, annotated by 35,000 people who logged on and identified locations of interest including military installations. In this mash up, regular citizens use social networks to make one of the most secretive regimes in the world amazingly transparent.

"North Korea Uncovered" challenges our very notion of truth. Our traditional worldview describes truth as that which can be authenticated by source. If we can authenticate the source, we set the bit as true. The information may still be erroneous, but we assign it to truth. Truth defined via social networking is different. It is regression to the mean and time changing. It is influenced by what we do and what we don't do. The mechanisms and tools we use to assess truth are different. And this truth, thus, requires a different world view.

Network Challenge. On December 5, 2009, DARPA began our exploration of these concepts. Namely, the power of social media to find things and the difficulty of assessing truth. The DARPA Network Challenge was a social network mobilization experiment to identify distributed mobilization strategies and determine how quickly a challenging geolocation problem could be solved by crowd-sourcing. Ten numbered, 8-foot, red balloons were simultaneously launched and moored in parks across the contiguous United States. The first person or team to report to DARPA the correct locations of all 10 balloons was awarded a $40,000 prize. A total of 4,367 individuals registered in the DARPA Network Challenge. To our knowledge it was the first large-scale social media experiment that included some adversarial component and significant efforts were devoted throughout the challenge to spoofing and masking the truth.

The winning MIT team correctly reported the location of all 10 balloons in an astonishingly short 8 hours and 52 minutes using a constructed and motivated network exceeding 5,000 individuals from just 4 initial nodes in less than 2 days. Indeed, we observed that social networks emerged or mobilized very quickly to solve this challenging geolocation problem. A significant number of the top finishers launched their team mobilization efforts with only a 1- or 2- day notice. Teams built around existing networks were able to mobilize their networks in less than a day. In one

case, a highly connected individual successfully mobilized his contacts through Twitter in less than an hour. Equally impressive, many of teams were able to do precise, targeted dispatching to verify balloon tips.

The DARPA Network Challenge revealed several promising means for using social networks to mobilize groups of people for a specific purpose and demonstrated the speed at which social networks could potentially be used to solve challenging, national geolocation and information-gathering problems.

Transformative Apps. Our next step will be focused on harnessing massive innovation in the development of applications ("apps"). Today's military handhelds, and the supporting network infrastructure, are designed to be highly robust and secure. Unfortunately, they are also fairly inflexible and very costly. New applications, and modifications to existing applications, can take years to field. Development is hampered by tight integration of hardware and software that is often generations behind commercial technology. Further complicating matters is the standard DoD practice to segregate users, requirements, and procurement in a highly disciplined process that does not permit a quick reaction in the face of rapidly changing user needs.

The goal of the Transformative Apps program is to place the right mobile software applications into the hands of warfighters as the apps are needed. As a result of this program, a diverse array of apps of national security relevance will be realized using an innovative new development and acquisition process. A military apps marketplace will be created to enable rapid innovation to meet user needs based on a direct collaboration between a vibrant and highly competitive development community and involved communities of end users. The program will address all the challenges – technical, business, and operational – to make the new capabilities available for use in the field. The objective is to transition the resulting systems to the end users in the Services and to foster a new model for rapidly and effectively acquiring, introducing, maintaining, and enhancing software.

As part of creating a military apps marketplace, DARPA will aggressively explore business models that can support the effort and provide alternatives to the traditional acquisition paradigm. New business arrangements and processes will be created that encourage broad participation from numerous development teams. We will explore appropriate rewards for the developers that are based on number of downloads, usage statistics, or other measures of

value to end users. The program will also explore alternative models for sustaining and enhancing the software in an efficient and cost-effective manner. Upon release of the Broad Agency Announcement, a buzz started. We counted 1 tweet a minute for 24 hours. Crowd-sourced, massive innovation of military applications the subject of over 1400 tweets? First impossible, then improbable. Perhaps sooner than we realize...inevitable.

This set of programs and ideas is almost overwhelming in scope and potential impact. But they 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.

Over the last 6 months, we have renewed our commitment to this ethic. We have aggressively engaged with three important constituencies: universities, industry, and the Services.

Over the last few years, the University community has articulated concerns about DARPA's commitment to basic research. There was much said on both sides about the veracity of these concerns. As I described previously, one of the elements of DARPA's success is the Agency's commitment to work at the intersection of basic science and application, so-called Pasteur's quadrant. The tension created in Pasteur's quadrant arguably serves as a catalyst for innovation. DARPA is not a pure science organization, but neither are we a pure application organization. We sit firmly at the intersection of the two and, to be successful, 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. This is almost a unique characteristic of DARPA projects, which are often multi-discipline, multi-community, and multi-stage.

University Outreach.

Upon arrival at DARPA, we were determined to understand and repair the breach with universities. We discovered the following: Between 2001 and 2008, DARPA funding to US research university performers did decrease in real terms, by about half. But, 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 multi-year commitments, to those with annual "go, no-go" decisions governing continued funding, which made it difficult for universities to commit to graduate students. A later stage focus resulted in more work done by universities as subs to prime contractors responsible for integration efforts, and the resulting flow-down of restrictions on the use of foreign nationals, export control, prepublication review, among others.

We assessed that we could address many of the concerns identified. So last September I traveled to five universities – Texas A&M, Caltech, UCLA, Stanford and Berkeley – to meet faculty, deans, and presidents, graduate students and undergraduates. The goal was to speak honestly and directly with them. We laid out the concerns, as we understood them, and the changes we had made or intended to make. We asked for their feedback. And we asked for their renewed commitment as well. For researchers to renew their commitment to working on Defense problems. For university leaders to clear obstacles and encourage their best and brightest to serve in Government. This service is, of course, in our shared self-interest because the quality of Government research sponsorship goes directly as the quality of the program leadership.

We continue to work on the issues: by educating our program managers to include basic research as an element in their programs, where appropriate, and to protect the integrity of this work under the provisions afforded fundamental research. The Agency has instituted new processes to ensure the necessary elements of academic freedom in basic research are balanced with the responsibilities of national security concerns. And we have increased transparency so that researchers can quickly determine whether restrictions apply to their work.

Since September, we have visited additional campuses across the country and spoken with university representatives to include Virginia Tech, Georgia Tech, MIT, and others. Our dialogue continues with more than 100 schools. We have more work to do, on both sides, but so far, it seems as if the breach is healing.

Industry Outreach.

Equally important, of course, is the role of industry: From electronics to pharmaceuticals, software to space, small businesses to large. On January 26th and 27th of this year, DARPA held an Industry Summit, the goal of which was to engage the leadership of US industry: CEOs, CTOs, COOs, and senior VP-level executives. These industry executives – 60 percent of whom were from small businesses – represent some of the best minds in the country. Our thought was that it would be productive to enlist them in the characterization of problems facing Defense of the Nation and in the generation of ideas.

More than 120 companies – Defense and non-Defense, representing more than 10 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.

Interestingly, we identified novel possibilities in a variety of areas, such as STEM education. Participants suggested a "Box O' Radar," a kit for teachers to give students hands-on experience with radar systems. The vision is that the children would actually build and use simple radars with wavelengths large enough to physically measure. We contemplated simple Doppler radars for motion sensing as well as basic pulsed radars. Additional ideas included the development of an application "marketplace" devoted to STEM that would post challenges such as "apps to teach electronics" or "apps to teach radar" or just "coolest app with a practical use." Industries motivated to increase the basic knowledge level and proficiency on such topics would also sponsor prizes based on download counts and/or by technical judging. Prizes might range from iPod's to scholarships.

Such initiatives might be interesting additions to existing STEM programs at DARPA, such as our Computer Science STEM Education program, which seeks to increase the number of students selecting computer science or a STEM major by providing age-appropriate, challenging activities and a sustainable infrastructure throughout middle and high school. Additionally, we sponsor InSPIRE, which utilizes microsatellites inside the International Space

Station as a platform for a series of student-led experiments and algorithm competitions, plus a crowd-sourcing experiment explicitly aimed at high school students.

Notably, industry had something to contribute to the STEM challenge. We discovered they are worried too and motivated to participate in the solution.

We had equally instructive exchanges on topics ranging from novel approaches to export control to cyber security. Participants had concepts for creating incentives that would better balance restriction of foreign access to key US technologies while ensuring the United States retains an industrial base for production. In cyber security, concepts for monetizing trust as a means for advancing our progress emerged.

The outcomes of the Summit were much broader even than these ideas and, admittedly, broader than we anticipated. Since it was an experiment, we did an extensive post-event survey of the participants. We contacted nearly every industry leader who participated. We learned that industry leaders valued the intensity of the exchange. They asked for a mechanism to continue the dialogue with the other Summit participants so as to continue to collaborate with each other. Further, nearly half of the participants told us that the Summit created the opportunity to build new business-to-business connections that they could not have imagined happening otherwise. An average of two participants at each table has already engaged in doing business together. DARPA served as the bridge.

Our Service partnership.

Our 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.

It creates an environment much like that experienced by athletes, where competition serves as a means of identifying winning strategies, and collaboration is a means of honoring higher goals. We agree to this collaborative competition because it works. But it is not without its struggles. Sometimes intense rivalries emerge; sometimes a referee has to intervene.

When the Secretary of Defense visited DARPA, I told him that if we do our job well, we would make him both very happy and very unhappy. Very happy because in DARPA's reach for new

capabilities that create strategic surprise, we often have intermediate landing points that significantly improve operations now. Very unhappy because sometimes DARPA advances promise to upend entirely what the Department is doing now. The collaborative competition necessarily involves some pain. But, at its best, when the equation is right, it's a powerful partnership.

Limited budgets focus activities; two wars intensify needs. Understanding how best to weigh the Department's responsibility to the present without sacrificing the future is critical. And each decision to apply resources comes with an opportunity cost. We found ourselves struggling with these very issues just within DARPA. With more than 100 creative program managers, the problem was not new ideas. The problem was deciding among them. We needed a strategy for balancing conventional overmatch investments with those devoted to thwarting insurgencies and terrorism. We came to understand that we could contribute significantly to understanding the decision-making space for highly complex problems.

DARPA has arguably one of the highest densities of technical subject matter experts in the Government. As such, we should devote effort to the formulation of the analytical framework necessary to sort through complicated ideas and to identify both gaps and opportunities that will guide both our internal investment decisions, and inform our engagement with the Services.

We call these analytical frameworks portfolio reviews. To date, we have completed a few. Global integrated ISR and tactical communications. We have others in work to include cyber, the delivery of lethal effects at distance, PNT (position, navigation, and timing), energy, and logistics, among others. These portfolios attempt to frame the discussion in technical and operational terms.

Let me give you an example from our global ISR portfolio. There is a near-constant complaint that we are drowning in data. So, we decided to assess exactly what this means. 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 see 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 see 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. Not surprisingly, 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 trend driven by increasingly demanding target sets 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 CENTCOM requirements alone and a modest deployment of the new high definition ARGUS-IS described earlier, the number of analysts required increases roughly fifteen fold.

What's the solution? Counter intuitively but very DARPA-like, the problem has in it the seeds of the solution. The better sensors are not only creating more data, but *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 10 times the frame rate. Ten times the frame rate means 10 times more data, but it also means that an automated system tracking a dismount or vehicle gets 10 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.

Such tracking algorithms, in concert with more accurate image analysis enabled by higher resolution, can be trained to identify and flag, video verbs such as "digging," "unloading," and "walking"; allowing more and more of the analysis of existing and new ISR data volumes to be turned over to untiring 24/7 automated analysis systems. Not humans.

These automated systems will free humans to do what humans do best and leave computers to do what computers do best. This resulting amplification of this matching means that the analysts needed to address the data growth is radically reduced. The need is now convergent with the capability. And we didn't give up our target set.

We have briefed the global integrated ISR portfolio to the JROC, to USD(I), to military advisory groups, and other senior leaders on both the Military and civilian side, and we continue to get requests. It has become an important tool. It catalyzed important discussions about how we predict or know the point of diminishing returns of more data, it revitalized our approach to the data exploitation problem, and it has become the source of shared understanding. It has built more bridges between the technical experts at DARPA and those in the operational community. We better understand the problem and each other. Transition is still a struggle, but now it's a struggle over how best to achieve the goals of global integrated ISR. A collaborative competition over how best to achieve the best capabilities for the Nation.

This is but a part of an overall strategy to stay close to our Service partners. To date we have met with JFCOM, SOUTHCOM, CENTCOM, STRATCOM, TRANSCOM, and SOCOM. We meet with the VCJCS, the Service Chiefs and Vices, those in the supporting S&T functions, as well as civilian counterparts. Additionally, we have open conversations with members of the Army Science Board, the Air Force Science Board, the Defense Science Board, and the NRAC, among others.

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 insanely great things. But getting them wrong can be a significant impediment. So, we have endeavored to be swift and aggressive about such matters. Since July 2009, we have:

- Wrung several weeks out of the procedures needed to get funds and supporting documentation to our contracting agents. This means that programs are underway, not languishing. And we regularly scrutinize programmatic and financial execution in each office to ensure we identify trouble spots early.

- Created an aggressive execution structure by shifting execution authority back to the program managers. Thus streamlining our decision making processes and putting DARPA program managers back in the role of running their programs in their best technical judgment.

- Stood up the Adaptive Execution Office (AEO) to harness the creativity of DARPA Program Managers and America's science and engineering community in the transition of DARPA technology to warfighters. AEO is about organizational relationships that connect warfighters to DARPA technology developers. The office is also taking a look at the transition worthiness of technology every step of the way, from inception to execution. AEO monitors the transition of programs and maintains a corporate memory of lessons learned. AEO provides support to current operations and is the primary interface with rapid fielding organizations across the Department.

- Created the Transformational Convergence Technology Office (TCTO) to explore emerging technological and social trends. TCTO focuses on the opportunities and threats of distinct, rapidly changing technology convergences. TCTO's research and development thrusts are interdisciplinary, spanning computing and computing-reliant areas of the social sciences, life sciences, engineering, and commerce. TCTO was responsible for the DARPA Network Challenge and continues to challenge the Agency's existing practices. They have spearheaded a pilot program on iPhone and Android use and, on February 27, started a contest to crowd-source the design of the TCTO logo. Over the course of 12 days, the staff provided feedback to 40 designers and reviewed more than 160 designs.

- Streamlined our SBIR contracting, creating what amounts to an SBIR "EZ" contract that utilizes commercial best practices and appropriate authorities. This removes significant barriers to the participation of small businesses in DARPA programs. It serves as a model for other Federal agencies.

And the list goes on...

Conclusion.

While we recognize the importance of measures of success, we also recognize the importance of wonder. DARPA has long been a place that nourishes wonder. Our recent Network Challenge captured the imaginations and wonder of many. I would urge you to go to YouTube and see the magic it created. It surprised even us. As humans and as a Nation, we need this sense of wonder. We crave it as children and as adults.

Forty years ago, the Internet was but a dream. We wondered… what's possible? Today, the Internet is commerce… it is a communal mind… the Internet is both vulgar and sublime. It has become a reflection of us, the human race…a vast, networked mirror that shows what we are and what we will become. And it has introduced a new generation of wonder in the power of social media, as experienced in balloon challenges, in the ability to transmit the bits that govern the organization of atoms in new vaccines. It has erased boundaries between people. It has created a new human geography, the implications of which we have only begun to understand.

What was once impossible, then improbable, and then inevitable. This progression characterizes DARPA's history, present, and future. The challenge serves as a timeless calling and source of wonder for the organization, for those in it, and for those near it.

American educator and poet, E. Merrill Root, is credited with saying "We need a renaissance of wonder. We need to renew, in our hearts and in our souls, the deathless dream, the eternal poetry, and the perennial sense that life is miracle and magic."

DARPA is the Nation's elite army of futuristic technogeeks. They are dreamers with V8 engines. This is their service to country.

Thank you.

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