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HEARING

ON

NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2009

AND

OVERSIGHT OF PREVIOUSLY AUTHORIZED PROGRAMS

BEFORE THE

COMMITTEE ON ARMED SERVICES
HOUSE OF REPRESENTATIVES

ONE HUNDRED TENTH CONGRESS

SECOND SESSION

TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE HEARING

ON

BUDGET REQUEST FOR THE DEPARTMENT OF DEFENSE SCIENCE AND TECHNOLOGY: RESPONDING TO THE 21ST CENTURY IRREGULAR WARFARE THREAT ENVIRONMENT

HEARING HELD
MARCH 13, 2008

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2008

THURSDAY, MARCH 13, 2008

FISCAL YEAR 2009 NATIONAL DEFENSE AUTHORIZATION ACT—BUDGET REQUEST FOR THE DEPARTMENT OF DEFENSE SCIENCE AND TECHNOLOGY: RESPONDING TO THE 21ST CENTURY IRREGULAR WARFARE THREAT ENVIRONMENT

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FISCAL YEAR 2009 NATIONAL DEFENSE AUTHORIZATION ACT—BUDGET REQUEST FOR THE DEPARTMENT OF DEFENSE SCIENCE AND TECHNOLOGY: RESPONDING TO THE 21ST CENTURY IRREGULAR WARFARE THREAT ENVIRONMENT

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE,
Washington, DC, Thursday, March 13, 2008.

The subcommittee met, pursuant to call, at 10:32 a.m., in room 2212, Rayburn House Office Building, Hon. Adam Smith (chairman of the subcommittee) presiding.

OPENING STATEMENT OF HON. ADAM SMITH, A REPRESENTATIVE FROM WASHINGTON, CHAIRMAN, TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE

Mr. SMITH. Good morning. We will call the committee to order. Thank you all for coming.

I would like to begin, actually, we are having a memorial service this morning—or had a memorial service this morning—for our troops who have died in Iraq and Afghanistan. And at 10:30 the House is observing a moment of silence, and I would like, if we could, to do the same here.

So we will start by observing a moment of silence.

Thank you.

Well, I want to thank our panel for being here this morning. I have some brief opening remarks, and then I will turn it over to Mr. Thornberry, who will have some brief opening remarks.

Then, actually, just for about five minutes if we could, before we get started with our panel, we have Dr. Schwitters, from the University of Texas, I believe it is, who has some expertise on the specific issue of managing our data. And there is a number of different aspects to that, but it is one of the more important issues that we are examining here, within the science and technology (S&T).

Specifically, what we are focused on is the bandwidth issue, and the problems as information warfare becomes more and more an everyday part of every single one of our troops' lives, you know, having them be able to access that. How can we manage all that is out there, take advantage of the spectrum we have?

And then the other piece of it, of course, is just managing, you know, the data in general, you know, whether you are, you know, communicating or simply trying to go into one of our systems and get some information out of it. The analogy that occurred to me, it is like classic professor's office that is now packed to the ceiling with papers and files and folders, and it is great to have all that information, but when you need one piece of it can you reliably get it?

And can you reliably get it if you are just an average everyday person and not some sort of computer genius? You know, basically, can our, you know, vast, you know, military establishment take advantage of that data and how can we better manage that? So we will do that in general.

But the main purpose of this morning's hearing is to review our Department of Defense's fiscal year 2009 budget request for science and technology. We have five witnesses with us here today: Dr. Allan Shaffer, who is the Principle Deputy for the Director, Defense Research and Engineering; Dr. Dom—I will go back to bed and we will just start over——

[Laughter.]

He can mispronounce last names, but when you mispronounce "Tom," you know you are off to a bad start. Dr. Tom Killion, who is the Deputy Assistant Secretary of the Army for Research and Technology; Rear Admiral Bill Landay, Chief of Naval Research; Mr. Terry Jaggers, the Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering; and Dr. Tony Tether, the Director of Defense Advanced Research Projects Agency (DARPA). We will take you in that order when we get started.

And I will just say a couple quick things. We are pleased that the budget request for science and technology represents a four percent growth over the fiscal year 2008 request. We have enormous needs in this area for some of the reasons I mentioned earlier.

As we move into a more irregular warfare environment that involves all kinds of different aspects of technology, it becomes more and more important that we stay on the cutting edge of that in order to keep up with our adversaries, to track what they are doing and also, you know, use those tools offensively as well. And there are dozens and dozens of different applications of that, which I won't get into—I will leave that to our witnesses—but I will say it is, you know, one of the most important things that this committee does, is try to figure out how to properly fund our investment in science and technology to keep us apace with that.

And I want to thank all of our witnesses in advance for the fine work that they are doing in these areas—incredibly complicated stuff, complicated stuff that changes moment by moment. Keeping up with it is definitely a fulltime job, and I think you guys are doing an excellent job of that, and we want to help you in any way we can to provide the funds to help you do the research and development that needs to be done in these areas.

And with that I will turn it over to my ranking member, Mr. Thornberry, for any comments he has.

STATEMENT OF HON. MAC THORNBERRY, A REPRESENTATIVE FROM TEXAS, RANKING MEMBER, TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE

Mr. THORNBERRY. Thank you, Mr. Chairman. I appreciate, as well, the witnesses being here today. This is always a little bit of a frustrating hearing for me, when we have it, because there are so many witnesses with so many issues, and I have so much to learn, and we have such limited time, that it just doesn't all seem to fit together.

It sounds like a cliche to say that today—that tomorrow's national security is dependent upon today's science and technology, but just because it sounds like a cliche doesn't mean it is not true; and I think it is. I also think it is one of the easiest areas of the budget to shortchange.

And I am not very pleased with a four percent increase. As you mentioned, the rate of change in the world today is extraordinary, and we are facing new domains of warfare; and to even hope to keep up with an understanding of what is happening, much less to do something about it, requires significant investments, I think, in science and technology.

I know that the organizations represented here are all doing great things. I will just say that I am most interested in hearing about the problems that you have—the obstacles that you have. Everybody has things to brag about, justifiably, but I think we are here to help the country, and we have to understand the problems and obstacles you face as much as the things that are going well for you.

So with that, I appreciate, again, all the witnesses and look forward to their testimony. I yield back.

Mr. SMITH. Thank you.

And with that, I will call up Dr. Schwitters.

If you could give us just a brief overview on the data collection issues, and we have a statement from you as well, which is in the record, which we will review at our leisure, but I am interested in any comments you have. And if you could—I know it is a big subject—if you could try to keep it to five minutes, just because we have a number of people on the panel we want to hear from.

STATEMENT OF DR. ROY SCHWITTERS, CHAIR, JASON STEERING COMMITTEE AND PROFESSOR OF PHYSICS, UNIVERSITY OF TEXAS AT AUSTIN

Dr. SCHWITTERS. Thank you, Mr. Chairman, for this opportunity. If you had seen my office you probably would have had second thoughts about this professor's office——

Mr. SMITH. Well, we are relying on your ability to manage data, not papers, so——

[Laughter.]

Dr. SCHWITTERS. So I am pleased to discuss with the subcommittee today some observations and suggestions for managing the prodigious quantities of data produced by new sensor systems increasing being planned and deployed in national security applications. As you mentioned, I prepared a written statement for the record, and I will briefly summarize some of that here right now.

Advances in microelectronics and related fabrication technologies enable new kinds of surveillance and monitoring systems comprising very large numbers of high-performance sensors that offer the promise of truly revolutionary advances in tactical intelligence and other pressing needs. I think everybody agrees, these are game-changing technologies if we can learn how to use them properly.

The potential of this technology currently is being hampered by inadequate analysis tools, which are not suited to handling the large quantities of data created by the systems. My comments today are drawn from interactions I have had with technical experts on new sensor systems and from discussions within my colleagues in JASON, a group of research scientists and engineers, largely from academia, who study technical problems related to national security for various agencies in the government.

In recent years our group has encountered the data glut problem in many different forms; for example, from tactical approaches to help counter Improvised Explosive Device's (IED) aimed at our troops in Iraq to understanding test results from prototypes of advanced systems. Several of us deal with these very similar issues in our own scientific work.

For example, now, a single modern aerial reconnaissance system may use 100 megapixel cameras operating several frames a second. They can generate 10 to 100 terabytes of data. Of course, these are—I am always reminded of some of the TV science shows where they say "billions and billions."

Terabytes today are the measure of data storage; you can buy a one-terabyte disc and it holds a lot of information. These systems generate tens to hundreds of terabytes in a day of observation.

I have been told that, for reference, that the—and this sounds low to me—but the estimated data rate between the Iraq theater and Continental United States (CONUS) is about 270 of these units per year, just to set the scale. So a single platform flying with modern sensors can easily swamp that kind of data rate in a day, with the kind of data we are talking about in a year of communications.

Merely increasing the capacity of our data channels won't do the job. In fact, flying modern discs on airplanes to analysis centers outside of theater provides pretty good bandwidth. But it is the analysis that must keep up with the flow of data to avoid pileup.

And I am reminded of the hilarious TV episode of "I Love Lucy," where Lucy and Ethel are at the chocolate factory and the chocolate just gets out of control, and you never get back in gear. The same kind of thing can happen. Well, discs do the same thing; they fall on the floor. And once you get behind, it is very difficult to catch up.

Furthermore, it is the quality of the information that can be derived from the new sensors that I think is of paramount importance. Photos and videos are no longer sufficient; the human mind can't keep up with that kind of information. So we need new ways to handle this data, and that is the issue in front of us.

The traditional approaches, for example, of compressing data, like video information, actually can harm the analysis value of the data; you lose critical information that cannot be retrieved unless that data are handled properly. These are simply new things that we need to deal with in addition to just managing the volume of data.

Now, I wanted to sort of raise with you the question of, you know, who is doing it right? Is anyone handling this problem in the science or technical community? And I think—and I would like to suggest—that there are good examples from the scientific research community for handling large sensor systems that actually go back to before the personal computing revolution.

In my statement I describe two current cases that I think are relevant to the discussion. One is from astronomy, called Panoramic Survey Telescope and Rapid Response System (Pan-STARRS), which is a large camera that actually has several hundred times the capacity of the best quality personal cameras you can buy in the stores today. These people are surveying the entire visible sky several times a month, and really revolutionizing our understanding of the cosmos.

The other examples I brought in the paper have to do with remarkable detectors being completed right now at the CERN Large Hadron Collider. These devices can swamp the data rates I mentioned earlier within a few seconds of information, and their goal is to learn about the smallest particles of matter and energy in the universe.

The sizes and data rates involved in both of these examples are actually much greater than those contemplated for tactical surveillance systems. They and other examples from the scientific community share important attributes, which are relevant to national security systems.

One: Scientific systems must separate very rare events with high efficiency from large backgrounds of ordinary activity. It is not practical to do this by analysts viewing pictures anymore. Automated quantitative forms of image analysis were developed to solve this problem.

Two: The quantity of data is strictly managed to maintain a viable analysis pipeline with priorities established by the science teams.

Three: The teams comprise highly integrated groups of hardware builders, software developers, and data analysts.

Now, what I have been describing here is essentially the business of systems engineering. And my basic point to the committee and to the people I talk to in the Defense Department on these questions is that we are facing really a new form of system integration here, and we all have to learn how to do this together.

This is not a solved problem. There are not standard theories of data fusion or compression that can be applied in a more traditional sense of system engineering. We have to learn a lot from the data itself.

So I would advocate that we think and try to, to the extent possible, establish integrated teams of users and builders—analysts, software developers, hardware experts—to understand and deal with the management of large data from the very design phases of these programs through their actual exploitation. I would like to see elevated support and recognition of the importance of quantitative data analysis in tactical and strategic systems.

And I would also advocate the commitment of some fraction of existing tactical intelligence resources—prototype sensor exercises and other opportunities for the entire community to learn how to do this tough job. There is a lot of learning ahead of us in this.

At this point, let me just close and recall that in fact, the World Wide Web was invented at CERN a generation ago to handle the problems of data glut and team communications in experimental high energy physics. I believe that more such discoveries await us that have the potential to change tactical surveillance and other areas of intelligence in ways as profound as the World Wide Web.

Thank you for your attention.

[The prepared statement of Dr. Schwitters can be found in the Appendix on page 37.]

Mr. SMITH. Thank you very much. And as we go forward, if we do have questions for you, when we get to the question period we will call you forward and deal with that.

In the meantime, we will turn it over to Mr. Shaffer.

STATEMENT OF ALAN R. SHAFFER, PRINCIPAL DEPUTY, DIRECTOR, DEFENSE RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE

Mr. SHAFFER. Chairman Smith, Congressman Thornberry, distinguished members of the subcommittee, thank you for the opportunity to appear before you today to describe the Department of Defense science and technology program. I ask that my written statement be entered into the record.

I am honored to represent the great accomplishments of the thousands of dedicated DOD science and technology professionals. Our program has a history of developing technologies leading to superior operational capabilities employed by the men and women serving in our armed forces today. While we continue to deliver superior capabilities, the new challenges we face drive us to evolve and expand our program.

The evolution of the national security environment, as outlined in the 2006 Quadrennial Defense Review (QDR), coupled with the emergence of an agile and global technology base has led to changes in the technology landscape for the DOD. Congress has recognized this evolving set of challenges and supported the DOD science and technology budget requests. For that, we thank you.

In response to the evolving need, the Department has experienced a decade-long growth in the science and technology budget request, culminating in this year's request of $11.5 billion, which is among the highest science and technology budget requests in history. Perhaps more noteworthy in the requested increase for this year is the requested increase for basic research, where we have an unprecedented 16 percent real growth in our request, to $1.7 billion.

Secretary Gates shaped this growth to begin to posture us for the future. This requested increase reflects the broad professional judgment of DOD's leadership, numerous Blue Ribbon advisory panels, and prominent industry executives, that our current military advantage is based on discoveries from basic research, and the belief that the long-running U.S. basic research leadership is in decline.

The growth in our requests are indicative of the continued commitment we are making to develop the technologies that support the future needs of the men and women in uniform. They deserve the best we can give them.

Over the past two years, we have begun to reshape the science and technology investment of the Department to increase the so-called "non-kinetic" capabilities by initiating or expanding programs in a number of nonconventional areas, such as biometrics;

human, social, culture, behavioral modeling; locating, tagging, and tracking; network science; persistent surveillance; and cyber protection. While we are currently well positioned to support the future force, there is still much to accomplish. We much simultaneously develop affordable technologies to improve current war-fighting systems, and address and integrate emerging technologies developed anywhere.

I know this committee is interested in how we are responding to the new areas of research for irregular warfare. I will use the example of handing large data sets generated by the explosions of the ubiquitous sensors and expanded communication capacity, but the process we use is similar for the other areas of irregular warfare.

The current projections are for the data volume of the defense systems to grow by as much as a factor of 1 billion over the coming decade, but the defense science and technology community is already planning for this growth through a multifaceted approach. First, in the fall of 2007, department science and technology leadership commissioned a large data handling technology focus team.

This multidisciplinary team used a systems engineering approach to baseline the current program, and then recommended a way forward. The principle that emerged—and this is important—is that DOD large data is not just about the size and amount of data, but the time to act. The team recommended several actions, from revamped architectures to processing closer to the sensor.

You have already heard from Dr. Schwitters, the chairman of the JASONs. We seek outside experts like the JASONs and the Defense Science Board (DSB) to provide independent assessments, which help shape our future.

But planning is not enough. We are also expanding the infrastructure to support development and testing of new algorithms and software to attack the challenge systematically.

In late 2007, we conducted a large data collection exercise called Bluegrass, in and around Lubbock, Texas, to simultaneously collected data from multiple types of sensors, such as radar, infrared, and other sensors. All this data is stored for the Department and Massachusetts Institute of Technology (MIT) Lincoln Laboratory, who make it available for others to use. We are attacking the challenge in a disciplined way.

Finally, we are investing in a number of large-scale demonstration programs to begin to test solutions. For example, the Large Data Joint Capability Technology Demonstration (JCTD) integrates bigger communication pipes with advanced storage systems and advanced data search and visualization software and methods. The first military utility assessment of this JCTD recently showed we could reduce tasks that used to take hours to minutes.

In closing, Mr. Chairman, I would once again like to thank the committee for the support of our science and technology program, and seek your continued support of the programs laid out in the fiscal year 2009 President's budget request. The ongoing emphasis of this Administration is to provide our armed forces the best technologies and capabilities we can by revitalizing our workforce and expanding the science and technology program into new and exciting areas.

With your help, we will succeed.

[The prepared statement of Mr. Shaffer can be found in the Appendix on page 44.]

Mr. SMITH. Thank you very much.

Dr. Killion.

STATEMENT OF DR. THOMAS H. KILLION, DEPUTY ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH AND TECHNOLOGY/CHIEF SCIENTIST

Dr. KILLION. Thank you, Chairman Smith, and distinguished members of the subcommittee, and hopefully my name won't come out like "dom," because I am just recovering from the flu. It might actually sound like that unintentionally.

I do appreciate the opportunity to come before you today and discuss the fiscal year 2009 Army science and technology program and the significant role that S&T is playing in supporting the war-fighter today and in the irregular warfare environment. I have submitted a written statement and request 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, 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 pursue technologies that will create unmatched and unprecedented capabilities for our future land combat forces. Our S&T program is also dynamic and responsive to the needs of today's soldiers by exploiting opportunities for near-term solutions to satisfy current operational needs.

We have already provided solutions to a broad range of these needs that have been driven by today's irregular warfare environment. We have developed and assisted in the fielding of passive armor solutions that provide tactical wheeled vehicles with ballistic protection that rivals that of combat vehicles; we have created improved soldier body armor that protects extremities; and we have provided detection and neutralization systems against improvised explosive devices.

Our investments in the quest for precision guidance in artillery munitions have enabled the guided multiple launch rocket system and the Excalibur precision 155-millimeter artillery munition. These capabilities have been decisive during today's irregular warfare combat operations, targeting the enemy while preventing unnecessary loss of life and harmful collateral damage. And, in a less materially-focused area, we have developed a training tool called Battlemind, which helps to prepare soldiers for the mental rigors of combat and aids them in preparing for reintegration when they return home.

While the focus of our S&T investments is necessarily on the near and midterm futures, we have also sustained our commitment to basic research that seeks to enable the next generation of soldiers with paradigm-shifting capabilities to dominate in the full spectrum of battlespace environments. Our fiscal year 2009 budget request provides increased funding for new research initiatives such as human, social, cultural, and behavioral modeling; modeling and analysis of complex multi-scale networks; and neuroergonomics. They will understand how the brain functions in an increasingly complex multitask environment, they enable more effective design, and guide enhanced training.

In closing, I would like to thank you, Mr. Chairman, for the opportunity to testify before the subcommittee, and for your support to the Army's science and technology investments. I am proud to represent the efforts of thousands of Army scientists and engineers dedicated to providing our soldiers with the best possible technology in the shortest possible time.

I will be pleased to answer your questions and those of the subcommittee.

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

Mr. SMITH. Thank you.

Admiral Landay.

STATEMENT OF REAR ADM. WILLIAM E. LANDAY, III, USN, CHIEF OF NAVAL RESEARCH, ASSISTANT DEPUTY COMMANDANT OF THE MARINE CORPS FOR SCIENCE AND TECHNOLOGY DIRECTOR, TEST, EVALUATION AND TECHNOLOGY REQUIREMENTS

Admiral LANDAY. Chairman Smith, Congressman Thornberry, distinguished members of the subcommittee, it is an honor to appear here today to update you on the progress of the science and technology efforts within the Department of Navy and to discuss how the President's budget request for 2009 supports the Navy and the Marine Corps team. I have also submitted a written statement and request that it be entered in the record.

The Naval science and technology challenge is to enable future operational concepts that support the vision of the Navy and Marine Corps as laid out by the Secretary of the Navy, the Chief of Naval Operations, and the Commandant of the Marine Corps. They envision a force that is joint, expeditionary, distributed, persistent, forward deployed, and capable of defeating a competitor in major combat operations or an insurgent force in nontraditional operations.

The President's 2009 budget requests $1.84 billion for an S&T portfolio that enables that vision. This reflects a 6 percent real growth over the President's 2008 budget request for the Department of Navy.

Our Naval science and technology strategic plan identifies 13 key areas where science and technology investment will have high payoff in supporting the Navy and Marine Corps war-fighting visions and needs. In order to execute this strategy, we must continue to address the changing global environment in the following ways: We must monitor, assess, and leverage emerging science and technology in a global manner. The increasingly rapid movement of technology and innovation around the world demands that we be able to take advantage of emerging ideas in science, regardless of where they originate.

We must maintain an investment portfolio that is balanced between the long-range scientific discovery that comes from basic research programs and the nearer-term focused product nature of the advanced technology development programs. We must focus on delivering value to today's war-fighters while ensuring that the well of new and novel technology development remains deep and vibrant in support of the next generation of sailors and Marines.

This year, we made a major increase in our investment in basic research to strengthen our efforts in emerging areas of science, such as autonomy, cyberspace, novel materials, and cognitive science, among others.

Finally, we must continue our efforts to aggressively transition the technology and innovative concepts to the war-fighters. Through our Future Naval Capabilities program, we are averaging over 80 percent success in moving science and technology developments into the acquisition programs, spanning the so-called "valley of death."

There are currently 169 Future Naval Capability products underway, in various stages of the three to 5-year development. Thirty-six are expected to complete and transition in 2008; an additional 20 are planned to complete in 2009. The fiscal year 2009 budget request continues funding for the remaining projects and initiates an additional 28 projects.

One of the key areas in our strategy is our ability to succeed in asymmetric and irregular warfare. Our goal is to enable naval forces to preempt or defeat nonconventional threats and forces operating within complex physical, cyber, and social terrains.

A key aspect of this strategy is the concept of operational adaptation. What can we do to enable our Marines and sailors to adapt, influence, shape, and act within the decision cycle of an adversary, even if that adversary is what would be considered an asymmetric or irregular foe?

Investments in areas such as imaging through structures; rivering operations; image and pattern recognition; societal, cultural, and behavioral modeling; biometrics; advanced training; and cultural immersion; and battlespace shaping through information operations will provide our Marines and sailors the ability to outthink and outadapt the enemy. This is about making the enemy fear us as the swift, flexible, unpredictable asymmetric threat.

We have a strong emphasis in today's needs, and a long-term focus on strengthening the Navy and Marine Corps' ability to meet any challenge and to adapt to any security environment. We continue to move toward greater integration of capabilities, more effective partnership between the research and acquisition worlds, and an ever-strengthening ability to achieve shared goals with Director, Defense Research & Engineering (DDR&E), the Army, Defense Advanced Research Projects Agency (DARPA), and Air Force research organizations.

I believe the state of our S&T investment represents a careful stewardship of taxpayer dollars that will make significant contributions to our war-fighters as they serve in defense of the United States, both today and well into the future. I thank you and this committee for your continued support of naval science and technology, and am prepared to answer any questions.

Thank you.

[The prepared statement of Admiral Landay can be found in the Appendix on page 85.]

Mr. SMITH. Thank you, Admiral.
Mr. Jaggers.

STATEMENT OF TERRY J. JAGGERS, SES, DEPUTY ASSISTANT SECRETARY OF THE AIR FORCE FOR SCIENCE, TECHNOLOGY AND ENGINEERING, OFFICE OF THE ASSISTANT SECRETARY FOR ACQUISITION

Mr. JAGGERS. Thank you, Mr. Chairman, members of the subcommittee and staff. I am pleased to have the opportunity to provide testimony on the fiscal year 2009 Air Force science and technology program.

Last year, I spoke extensively about adapting Air Force S&T to the new security environment identified in the Quadrennial Defense Review. Recall, I presented our new Air Force S&T vision: to anticipate, find, fix, track, target, engage, and assess anything, anytime, anywhere as our guide for shifting investment emphasis from traditional conventional threats to address new unconventional threats, such as terrorism. I am proud to say that this budget continues to reflect a shift toward this vision and the new security environment.

Also recall that in 2005 I established five guiding principles for the Air Force S&T investment program. These principles have provided a valuable framework in constructing this budget.

Developing, recognizing, and ensuring competent, technical, intellectual capital exists in the laboratory and elsewhere across the Air Force as my number one guiding principle. As functional manager for the 15,000 scientists and engineers across the Air Force, my commitment to the development of the 3,300 scientists and engineers in our laboratory is paramount to maintaining our national aerospace power.

My second guiding principle is to ensure a balanced portfolio of investments between near, mid, and far-term needs. To ensure our far-term needs are met, we allocate no less than 15 percent of our core portfolio to our 6.1 basic research efforts. To meet near-term needs and ensure technology solutions are transitioned to both the war-fighter and our acquisition programs, we allocate no less than 30 percent of the portfolio to 6.3 advanced technology development efforts.

My third guiding principle is to focus our resources on the strategic priorities of the Air Force, the Department of Defense, and the nation. To this end, our budget reflects significant focused investment changes to which I will speak to shortly.

Honoring commitments is my fourth guiding principle. Collaborative research with my colleagues seated next to me, academia, industry, and our allies, as well as transition agreements with warfighters and Program Executive Officer's (PEOs), were all protected in this budget. The Air Force seeks out collaboration and we stand by promises that we make.

Last, but not least, of my guiding principles is to find new and improved ways of transitioning technologies directly to the warfighter in the field or into our acquisition weapon systems. I am proud to say that this year we are establishing a new Technology Transition Office within Headquarters Air Force. I have challenged this office to develop a comprehensive strategy for overcoming transition obstacles related to laboratory S&T, joint capability technology demonstrations, rapid response to urgent war-fighter needs, small business innovative research, and partner transitions to the Air Force from DARPA and others.

Our 2009 President's budget request for Air Force S&T is approximately $2.1 billion, which includes $1.9 billion in core S&T efforts, with the remaining funds supporting devolved programs to include high energy laser and the University Research Initiative. This year's budget request includes an increase of $157 million, or a 6.7 percent real growth, over fiscal year 2008 core requests. Even taking the $40 million of Man/Tech funding that was moved into S&T this year out of the equation, it still represents a very health 4.5 percent real growth and reflects the continued strong support of Air Force leadership for its S&T program.

Earlier, I had mentioned some significant focused investment changes we made to this year's budget. First, we shifted over $20 million across the Future Year Defense Program (FYDP) from traditional investment areas to new areas that anticipate terrorist actions and tag, track, and locate these bad actors anywhere on the globe 24/7.

Next, we shifted almost $200 million across the FYDP to increase focus on game-changing technologies to guarantee modernized systems have technological superiority on the battlefields of the future and against today's terrorists. Specifically, we increased investments in cyberspace to help our new cyber command fight through network attacks, in defensive counterspace to respond to the national Space events of last year, in directed energy for both nonlethal deterrence and ultra-precision strike, in revolutionary propulsion such as hypersonics and variable-cycle engines as suggested by a National Research Council study, and in thermal management technologies in response to a Scientific Advisory Board study that suggested looming thermal problems for our complex weapon systems of the future.

At the same time, we protected game-changing investments that were in the 2008 budget that support the Air Force energy strategy to develop alternative fuels, efficient engines, and aero-efficient structures, an advanced composite cargo aircraft project that provides a capstone to our Composite Aircraft initiatives to reduce aging aircraft sustainment issues, and sense-and-avoid technologies for unmanned aerial systems to operate them in theater or domestic airspace as ubiquitous as piloted vehicles are operated today.

Mr. Chairman, this budget is aligned in three priorities of the Air Force: to ensure technology is transitioned to war-fighters with the expediency necessary to win the global war on terror, to develop our airmen as future technical leaders and ensure we have a competent workforce skilled in managing the complex weapon systems we will need for the future, and to ensure our research and development dollars are focused on modernizing and recapitalizing weapon systems critical to airspace and cyberspace dominance to ensure the Air Force can fly, fight, and win in any future conflict.

Again, Mr. Chairman, members of the subcommittee and staff, thank you for allowing me to provide an opening statement, and I look forward to your questions.

[The prepared statement of Mr. Jaggers can be found in the Appendix on page 99.]

Mr. SMITH. Thank you very much.

Dr. Tether.

STATEMENT OF DR. ANTHONY J. TETHER, DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)

Dr. TETHER. Chairman Smith, Congressman Thornberry, and distinguished members of the subcommittee, thank you for having me here today to describe DARPA's current research and our plans under the fiscal year 2009 budget request.

This February was our 50th anniversary. My written testimony looks back over what we have done in the near past, since 2001, and highlights our progress in eight big deals, as well as the future. These big deals include: deny hiding in any environment and cultural background, providing persistent situational awareness and rapid strike, removing the value of using biological weapons, increasing the survival from life-threatening wounds.

I enjoyed writing this testimony since it gave me a chance to explain DARPA and to brag about the accomplishments we have made since 2001, and those in progress and yet to come. But please read it when you get a chance.

The facts are, however, that we couldn't have done all this without a lot of outside help. But the help from the Congress, and this committee in particular, has been and will continue to be necessary for DARPA to be DARPA and to continue doing what we do.

I heard from your staff that you are interested in large data set analysis. Because of that, I will spend a few minutes expanding on the written testimony and describe what DARPA does in this area.

First of all, there are many levels of large data set analysis. The data from sensors such as Constant Hawk, and so forth, is most certainly large, and we do research in how to help people find targets of interest.

But to me, a more interesting large data set problem is when you really don't know a priori what you are looking for, or even if there is any information in the data. After all, it may be just random.

Well, we call our most sophisticated large data set research "topological data analysis." Our large or massive data sets topological analysis program uses very sophisticated topology and geometry to capture the intrinsic geometry of massive data sets, and systematically extract hidden features therein.

All that is needed to start the mathematics is a metric, such as the distance between any two data points in the set. Now, the distance doesn't have to be things like feet; it could be temperature, it could be density, it could be anything you want it to be.

We have some current accomplishments. This analysis was applied to analyze massive data sets in biology—collections of heartbeat data for health and diseased patients.

The data for healthy heartbeats appears to capture nontrivial higher geometric structure than those for diseased patients. In other words, there is a difference between the two. This work is just beginning, but the potential is absolutely enormous: statistical markers for health and disease.

It has also been applied to uncover unexpected high-dimensional structures in the statistics of natural images. Applications include novel, nonlinear compression schemes, as talked about earlier, for images and movies. This would greatly aid systems such as Constant Hawk in getting the data directly to the ground faster than possible today.

By now, I am sure some of you are saying, “Well, there he goes again. Is he ever going to tell us anything relevant to, you know, to what is going on in the world as we know it today?” And the answer is that there is relevance to IEDs. There is great relevance, in fact.

First, I cannot go into any specific details, due to the sensitivity of exposing countermeasures to the IED problem; but we have a program called Persistent Operational Surface Surveillance and Engagement (POSSE), joint with Joint Improvised Explosive Device Defeat Organization (JIEDDO), which has been briefed to your staffs, whose objective is to determine if there is any difference between a facility that makes bombs and an ordinary Iraqi facility.

To do this, we have established an experimental capability at the National Training Center, at Fort Irvin, where we are going to gather an extremely large data base on all activities—normal Iraqi facilities and bomb-making. We hope to use techniques such as topological analysis to determine if there is any underlying structure to the data, with the hope that the structure you get from data coming from a bomb-maker’s facility is different from an ordinary facility, thereby allowing us to find out where they are being made.

This is really exciting. While I don’t know the outcome—because if I did, DARPA wouldn’t be doing it—I am confident that tools such as topological analysis will answer the question, whether it can be done.

I hope I have provided you with some insight into what we are doing in large data analyses, and request that you scan my written testimony to see what we have done and will be doing elsewhere. Again, none of this could be possible without the support you have given DARPA.

I want to thank all of you personally, and from all of the DARPA employees as well as all our industry and university performers, for your support. We hope that this support continues into the future because without it, DARPA will not make it to its 100th anniversary.

With that, I would be glad to take your questions.

[The prepared statement of Dr. Tether can be found in the Appendix on page 113.]

Mr. SMITH. Thank you all very much. I appreciate it. And I appreciate the members’ patience; as Mr. Thornberry mentioned, this is a whole lot of information in a whole lot of different areas. We are going to have some hearings that drill down into some of the specifics here on social modeling, on strategic communications, and also on biometrics, which we set up to help us get down into some of those specifics.

And Dr. Tether, I specifically want to thank DARPA for their work on health care issues. You know, many of us here saw your prosthetics demonstrations on the advancements that have been made there, and some of the technologies that have been developed to enable battlefield survivability have been just incredible.

And I know you are moving forward and taking the next steps on, you know, going beyond that and coming up with even greater health care advancements. I think it has been critical to our troops, and we appreciate that work.

I want to ask specifically, you know, trying to follow up a little bit on the data management and bandwidth issue. Focusing on bandwidth for just a second: What does the solution look like, to your mind, in terms of the investments we are making?

Because expanding the bandwidth really isn't an option; what we are trying to do here is we are trying to use less of it with what we do. And I know there is a number of technologies—we had a little science fair on this. Just from your perspective, you know, where should we be putting our money? What technologies are really going to get us up around that problem so that we can make more of the bandwidth that we have?

Dr. TETHER. Well, there are really two. One is that you can take the signal being transmitted and compress it so it takes up less bandwidth. That is sort of an obvious——

Mr. SMITH. Right.

Dr. TETHER. And we are all working on doing that type of technology.

The other technology, that is actually coming into being as we speak, is at one time we looked at the spectrum. And the spectrum, as you all know, is 100 percent allocated, or licensed. And we asked the question, "Well, how much of it is really being used?"

And we did measurements, and we found that at any given amount of time, typically only 5 percent to 10 percent of the spectrum is being used. In other words, there is 20 times more spectrum available than what is being used right now.

So what we have done is, over the last five, six years we have developed technology where radios—networks, actually—will look at the spectrum, find out what is not being used, and then go to that frequency, create itself, and then be prepared to move if something came on. This is real. I mean, I just said something that requires a lot of technology: the ability to golf in gigahertz of bandwidth, find out what is not being used, and to coordinate all of these nodes together.

But it is no longer science fiction; this is actually in play. We have demonstrated this at AP Hill.

We are also putting it into radios right now, which are going to be going into service later this year. Now, this will take place because, quite frankly, this is a commercial thing as well. Our Federal Communications Commission (FCC) believes in it. In fact, they call it "policy demand," or something like that. They are going to make up rules that these systems will follow. And I know it will take off.

That, I think, is the biggest gain we can get in bandwidth by effectively—the bandwidth that we are using today is 1/20th to 1/10th of what we could be using, so we will get that gain. And you put, then, the gain on top of that—the compression techniques—which might give you another factor of two, of using less bandwidth, and I think our problem will be—well, probably never—because——

Mr. SMITH [continuing]. It will be much more managed. And the technology basically enables you to seek out and find the bandwidth that is out there and available. And, I mean, this will make an enormous difference for our troops in the field being able to communicate just by radio, and it is not even just the laptop, of, you know——

Dr. TETHER. Correct.

Mr. SMITH [continuing]. Can you get all the data. It is just being able to communicate with the various different pieces of it. I——

Dr. TETHER. One more effect, that if we don't know what frequency we are going to be on, neither does the enemy. Which means now, if we are going to be—if the enemy is going to try to jam us, they have to jam all the frequencies, because we will be on—otherwise we will be on the frequency that is not being jammed because the system will automatically go to——

Mr. SMITH. Automatically take us to where we need to go. I have other questions. I want to get Mr. Thornberry in before we go. We have, I believe, two votes. Is that correct?

We are tabling more emotions and voting on the journal again. Make an argument about whether or not it is worth the trip over there.

But we will go. I want to get Mr. Thornberry's questions in, and then we will come back, my guess would be—being realistic—40 minutes, probably, from the time we walk out of here to the time we get back. Because I do have other questions, and I know it is hard, but I would encourage other members to come back and we will get to them as soon as we do.

Mr. Thornberry.

Mr. THORNBERRY. Thank you, Mr. Chairman. I think I am going to wait with my questions and yield my five minutes to the former chairman, the gentleman from New Jersey.

Mr. SMITH. Mr. Saxton.

Mr. SAXTON. I believe it was Mr. Jaggers—I am not sure—that talked about sorting through data to find where someone we are looking for might be and identify potential terrorists someplace in the world. Recognizing this is an open session and not a closed one where we can talk in detail, could you enlighten us a little bit more on that concept?

Mr. JAGGERS. I think I specifically said we were focused on increasing investments and shifting our investments from traditional threats to unconventional threats—terrorists—into the anticipate leadership—bad leadership—intentions, and to the tracking enemies—targets—anywhere, anyplace on the globe, 24/7.

We have a number of areas. Three come to mind that I think I would like to present right now.

One is deployed currently. It is called Angel Fire; it is being used by the Marine Corps. We worked very closely with them, and a lot—most—of the technologies on the sensor part came from the Air Force Research Laboratory.

And I brought this up last year. It provides kind of a TiVo picture review. Like, you could see an electro-optical (EO) picture of the battlespace, and then you can rewind and do forensics to see, if an IED went off, where the bad guy came from, to attribute the source and do some forensics.

We have another effort, and that is an EO system, a day system, that is an all-weather system—day/night—which uses Synthetic Aperture Radar, SAR, technology called GOTCHA. It does basically the same thing, but it does it in an all-weather situation; again, to tag, track, and locate where these bad guys—not only where the event occurred, but where they came from, and go back to the source of the problem.

We also have a significant investment in bio-taggants. While that can be used for individuals, it is specifically used for weapons of mass destruction—chemical, biological warfare agents—so we can put a biological taggant on those materials and now track and see where they go, in theater for sure, but hopefully anywhere in the world.

Of course, I am probably causing the increased requirements in bandwidth as a result of this. So I am part of the solution, but part of the problem, too.

Mr. SMITH. Well, as long as you are using it well, we will try to find ways to accommodate.

Mr. JAGGERS. But probably the good outweighs the bad on this. Those were three examples, I think, that we are trying to——

Mr. SMITH. I think we will try to sneak one more in before we go.

Ms. Castor.

Ms. CASTOR. Thank you, Mr. Chairman.

With the evolving global threat turning into more of the unconventional and irregular warfare, the responsibilities of Special Forces will continue to grow and evolve as well. Special Operations Command (SOCOM), for fiscal year 2009, their S&T request is around $65 million; that includes $11 million in the new area designated for Special Operations Forces, information broadcast systems, advanced technology.

Mr. Shaffer, can you briefly describe how the Special Operations S&T requirements fit in overall, to the overall DOD S&T requirements, and their—you know, the SOCOM procurement is tied to the various services, and I imagine that is—I hope that is not the case for scientific research.

Mr. SHAFFER. Thank you.

There are a number of ways, and as we have gone forward, we have reached out and tried to strengthen the ties between the gentleman at the table, DARPA, and also the folks in the agencies in SOCOM. So we have a fairly well established set of processes to coordinate the programs.

I would like to give a couple of examples. One of the biggest problems—and Mr. Jaggers talked about it a little bit—was going out at finding terrorists—tagging, tracking, and locating problem.

It gets to be very classified very quickly, but last year's SOCOM and some other components worked with DDR&E and the component to develop the tagging, tracking, and locating roadmap. From that roadmap we, across the Department, increased our investment specifically in some of the special—the SOCOM science and technology program elements, and also some Army program elements, to go out and increase basic research through product development in tagging, tracking, and locating.

So, SOCOM is very much a part of our process. We recognize they have special needs, special types of activities. We work a lot with SOCOM through some of our newer offices that deal with irregular warfare.

We have a new office in the Office of DDR&E, called the Rapid Reaction Technology Office, who specifically look at irregular warfare and trying to look for technology options somewhere in the next two years—two-year time horizon. That office has a weekly teleconference with members of SOCOM, the Joint Special Operations Command, and also theater commanders forward, to specifically review technology options, and specifically as that relates to irregular warfare.

So we have done a lot of different things. That office got the DDR&E and the Department much more involved in the problem of biometrics.

It has gone into areas of social, culture, behavioral modeling that is very important to the special operators. They have gone into strategic—it is called strategic multi-layer assessment, where we bring in folks from psychology backgrounds, anthropology backgrounds, war-fighters, put them all in a room, and ask them to red-team some problems or do some war-gaming with nontraditional people, who would reach out very, very carefully to SOCOM and integrate their program.

But we don't want to get in the way in stopping it because we recognize the types of special missions special operators have to do. We want to support them, give them the additional technology they need, and we get a lot of support from the components working with SOCOM also, directly.

I hope that addressed your question.

Mr. SMITH. We are down to about five minutes before we vote, so we will adjourn briefly. Actually, we should be able to be back, hopefully, in 20 to 25 minutes, and we will take some more questions from whatever members come back, and we will try to—we probably be adjourned no later than 12:30.

Thank you very much. I apologize for the delay; we will be back as soon as we can.

[Recess.]

Mr. SMITH. Thank you. Quicker than I expected. That doesn't happen very often around here.

And the award for the first to return, we will turn it over to Mr. Kline for questions.

Mr. KLINE. Thank you, Mr. Chairman.

Thank you, gentlemen, for being here, for your testimony, for your hard work, and all the great things that you do.

Dr. Tether, I love this. You know, as we have been talking for a number of years, there has been a great need to facilitate private industry, small businesses—and large, but particularly small businesses—and their ability to bring ideas to you and to conduct business with you. So I am very, very pleased to see this.

And on the same lines, I am looking at this—another really neat document. On page 45 in your additional information, you talk about a special assistant for technology transition and the DARPA operational liaisons and representatives.

And so, what I would like for you to do is just tell us how you have moved into communicating interservice, intradepartment, and more specifically this, and what your sense is now of how that communications is going.

Dr. TETHER. Well, it is always very hard to measure on how it is going. We do try to—I have always been concerned that we aren't reaching out to all the people that should know about us. It always still amazes me when—and this is, you know, I mean, I like it, but—when you have a constituent that comes to you, and your staff comes to us, when, why didn't they come to us in the first place? Well, for the most part they didn't know about us. But that bothers me.

And it still bothers me, and that is why we work hard. We have this DARPATech, we work really hard on trying to get out that we really are a friendly place, and—but, you know, that doesn't mean that, you know, we don't enjoy your constituents that come to us that way, too; because quite frankly, they come with good ideas. You know, as I said once before, we accept—good ideas come from any place, even the Congress, right? I mean——

[Laughter.]

Mr. SMITH. Let us not take it that far. Come on. [Laughter.]

Dr. TETHER. On the operational liaisons—in fact, I have them here with me today—we have one from each service. We have one from National Security Agency (NSA), one from Defense Information Security Agency (DISA), and one from National Geospatial-Intelligence Agency (NGA).

So we have one from each service and agency that does a lot of business with us, and their purpose is to take our program managers, who, as you know, are really only there for a short period of time, and they really have come from places where they sometimes they really don't understand the government or the military, to make sure that that program manager, from the very beginning, meets an operator—not an S&T guy, you know, we get enough of these guys—but to go out to an operator so that program manager can explain what he is doing.

That gives us two things: the operator learns that something new is coming; more importantly, from my viewpoint, the operator talks to my program manager and tells him about his problems and his needs, and we get that going. So when the technology then gets developed, when it is time to transition it, you know, we have already established, if you will, a constituency about it.

Because quite frankly, transitioning this technology—all these reports, all these briefings—this is a contact sport. You know, it really is a contact sport on transitioning technology; it comes down to people on people to make that happen. And again, you know, we really work hard at that.

The interns are another way that we do this. These are a group of people that come every 3 months—about 10 to 12 of them—from all walks of the services. They are picked by the chiefs of the services to come to us.

In fact, I have them with me, too. They love to come and see what goes on, you know. And this is our current group. Now, we have had almost 100 of these since we started this program, and these are 100, if you will, people that are now back at the services.

They are only with us for three months, which means that they leave with a little DARPA stink on them—not enough to screw up their career, hopefully—but it is now people that we have out in the services who know about us. And again, it is trying to get that word out about DARPA. We work hard at it——

Mr. KLINE. Well, I appreciate it very much, because I think we need to do all of those things, and certainly the transition, and clearly there are good ideas out there, and as you know, particularly at your level, a lot of this isn't requirements-driven so much. People haven't even thought of what you are putting forward——

Dr. TETHER. Correct.

Mr. KLINE [continuing]. So that communication is absolutely terrific. I am about to get the red light here, so I would just make a comment, and maybe we will have a chance to talk about it later. It is very clear that all of our services are increasingly dependent upon GPS for so many things—precision munitions, navigation, and everything.

And I would hope that somebody—probably under the DDR&E hat—but somebody is constantly looking at how we are going to protect that and make sure that we haven't bought into a vulnerability by making so many things depend upon it for the naval munitions, Army munitions, and across the board. I see the light is red; if we have another chance, I would like to have some dialogue——

Mr. SMITH. Yes. Hopefully we will.

Mr. Thornberry, you had graciously passed. We want to go back to you.

Mr. THORNBERRY. Thank you, Mr. Chairman.

I guess I want to ask about a couple things, the way they work or not.

Dr. Tether, I noticed in the information we had received from the staff, as well as from your testimony, there was comment about money being rescinded out of your budget in the past due to poor execution rates. It is something that has always bothered me, that if an agency doesn't spend their money we decide they don't really need it and take it away, creating the incentive to spend the money regardless of whether one spends it well or not.

So I am just curious, are the rescissions that you have had something that have been not that bad? Has it had a detrimental effect? And how does that affect your ability to do your work?

Dr. TETHER. Well, you know, we have a major ongoing conversation with the comptroller—I will call it a conversation. We operate differently than the rest of the Department in that when a—at the beginning of a fiscal year, if a contractor—performer—is under contract, and let us say they have a milestone halfway through the fiscal year—we call the milestones "Go/No-Go's" because is sounds more turconian, but, you know—they will fund the whole year.

Now that, from the comptroller's viewpoint, that means that that person is 100 percent obligated. However, we don't do that; we only fund the contractor up to that Go/No-Go, and hold the money. So from the comptroller's viewpoint when they look at the books, we look like we are 50 percent obligated because we are holding back that money.

It causes a strange dynamic when you work it that way. If you have got all your money with a contractor and the contractor doesn't make the milestone, then the pressure is to let them keep going because the money is already out there.

In our case, the pressure is on the contractor to perform. And what sometimes happens is that while we had a date for them to do that Go/No-Go, they sometimes don't do it on that date, they do it a few months later, and they don't ask for any more money.

So if you take that with a $3 billion budget and have everybody slip a month, you are talking a couple hundred million dollars of cash that you have now generated—you know, from a bean-counting viewpoint. And the comptroller looks at that as, "Hey, you know, I have got other things to do with this." And it is okay, actually. You know? It is okay. I don't like the trend, but it is okay because we do generate cash, because we are very frugal with the way we spend money.

But what it does—DARPA's really success has always been that we have the flexibility—and you guys have given us this flexibility—that if somebody walked in the door with a good idea, we could start a program and wouldn't have to wait two years, which is what the services sometimes find themselves in. And that is the danger.

But the money that has been taken so far—yes, you know, I have had to prematurely kill a few programs that, in reality, I figured weren't going to make their Go/No-Go's anyways. And it turned out that that was the case. But I never gave them the chance; I mean, I never gave them the chance to fail, they just failed because of the money being taken away.

I hope that answered the question.

Mr. THORNBERRY. No, it is helpful. I think it is something we want to continue to watch with you, because again, it sometimes doesn't make sense.

Mr. Shaffer, let me ask you—this is a broad subject; we don't have time to get into it too much—but, in another hat, on the Intelligence Committee we just had a hearing about the Research & Development (R&D) efforts of that community, and I am struck not only by the overlap between what you all do and what the Intelligence Community does, but the overlap with the medical research, and everybody and their brother is doing cyber research of some sort, and, you know, you just go down the line.

As the domains of warfare have expanded, that means the potential overlaps in—which is good; that means more people are looking into it—but the challenge is, how do you coordinate all that? One of the major concerns, I think, of this subcommittee and other subcommittees is this interagency, working together, not just having a teleconference every other week, but how do you really make sure that the money that these folks are spending on cyber fits with the money that other folks are spending on cyber, and other——

And that is too broad a question to answer fully, but let me—how do you evaluate the current S&T interagency coordination, if you had to give it a grade from "A" to "F"? And are we getting better or are we getting worse?

Mr. SHAFFER. Sir, I will give you a grade, but then I want to amplify on the grade. We are probably about a "C." We could do better; we could do worse.

But I want to come back and react a little bit to something you said early on about, there seems to be a lot of duplication. And there may be some duplication, but there is a whole lot more cooperation than duplication.

So a lot of times you go out to folks and two people will tout a similar thing. What is really happening is they are collaborating and both people are claiming credit for it, but they are sharing their money and working together.

Case in point: This year it didn't happen, but last year when we looked at the science and technology statements from this panel, I think every service claimed some success with a program called Angel Fire—Mr. Jaggers talked about it today. Well, the reality is, we all had a little skin in that game.

We have skin in the game with Central Intelligence Agency (CIA)—very much in the Intel Community, coordinating our program. Dr. Tether, I know, has a liaison with the intelligence agencies; I think most of the other gentlemen do, too. And we coordinate our program very carefully.

We do—I would like to tell you it is detailed program reviews; it is probably not as detailed as it should be. But we all get together and compare programs and pool money where we can, because while it sounds like a lot of money, $11 billion just doesn't go as far as it used to; and if I can use a little bit of someone else's money to make a program go better, we will do that.

And you asked about cyber protection. Great question. Because we recognize that a lot of groups were jumping on the cyber protection bandwagon—and this actually came out of the Office of Science and Technology policy—they pulled together what effectively is a Presidential coordination committee to get the programs together, get them aligned, and make sure that we are leveraging each other's money.

So before calling something duplication, I would ask that we need to pull the string and make sure that it is really not leveraging and working together; because a lot of times that is the case.

Mr. THORNBERRY. Yes. And I think you make a fair point, that marketing departments of different agencies will triumph the same thing. Fair point.

On the other hand, if you get a hot trend, everybody wants to jump on that bandwagon and, you know, it is not necessarily a bad thing to have different people looking at a problem in different ways—I am not saying so—but on the other hand, we also have to make sure that it is something more than a trend and that we are really working together. So I appreciate it.

Mr. Chairman, I would yield.

Mr. SMITH. Thank you, Mr. Thornberry.

Mrs. Gillibrand.

Mrs. GILLIBRAND. Thank you, Mr. Chairman.

I want to continue the conversation about cyber security, if I may. One of the concerns that I have is, obviously for this subcommittee it is one of the very real threats we face, and I want to make sure that we are committing the appropriate resources—sufficient resources—specifically for it.

And I also want you to comment on how our recruitment is doing. I am concerned that if we are going to build the talent pool that we need to stay at the forefront of cyber-terrorism defense, that we may need to recruit outside the box—really looking toward our engineering schools very proactively and trying to create a military service training and capacity that may be different for these types of members of the military; because they may not be hired for combat missions, for example, they are hired for development in science and technology in their engineering background, and they may have a different pay grade, they may have a different work environment.

And I want to hear more detail about what you have considered, what has worked, what hasn't worked, and really what your five-year plan is.

Mr. SHAFFER. Yes, ma'am. And I may yield a little bit of the time for the cyber protection to——

Mrs. GILLIBRAND. Whoever is the most appropriate to answer——

Mr. SHAFFER [continuing]. But I would like to address the cyber protection question first. You asked—because it is a hot area—do we have enough investment in it? Do we not have enough investment? Frankly, I am not sure I know right now.

I know we have a solid program going forward, but because it is a new area, we have a very detailed ongoing study with members from each of the agencies represented at this table—and we are due to report this to the deputy secretary by this summer—on what is the right amount and shape of our science and technology program needed specifically for cyber protection? So I can't give you a really finite answer right now; I can tell you, we have a due out to the deputy secretary to come back and tell him how much.

So, what I would propose to say, rather than give you an answer right now: We are comfortable with the 2009 budget request, but I think that there is more——

Mrs. GILLIBRAND. I thought we were underfunded in science and technology by several millions of dollars.

Mr. SHAFFER. In cyber protection?

Mrs. GILLIBRAND. No, just in science and technology in general; so I didn't know how much would come out of cyber protection.

Mr. SHAFFER. Again, I don't know how I would address your question about being underfunded in science and technology. Science and technology in general, we are at $11.5 billion, and the seven largest requests since we went to this budget process in 1962 have come in the last 7 years.

So, you know, could we use more money? I would always love more money. But historically, we are funded fairly well right now. What we have to do is make sure that what we have, and the money we have, is invested correctly and providing good taxpayer benefit.

So that may not be exactly the answer to your question, but you know, we are all taxpayer stewards. And you have to go ahead and make sure that whatever we spend, we give something back to the taxpayer. And cyber protection is a hard area.

Mrs. GILLIBRAND. Yes, I think we are—under this briefing, we are down $20 million for advanced tactical computer science and sensor technology; DARPA is down $33 million; there is a number that are down in the high-tech region; aerospace technology development down $20 million.

Mr. SHAFFER. Ma'am, and there are specific lines that are down; there are other specific lines that are up. What I will tell you, ma'am, is over the last three years—or last two years—we have reshaped our science and technology program over the FYDP, the Future Year Defense Program that is five or six years, by moving about $3 billion total assets over that time period into things like biometrics; human, social, culture, behavioral modeling; cyber protection.

We did have some other funding come up in cyber protection in 2009. So you are going to see ebbs and flows in different areas, but for the most part we are moving money into irregular—technologies to help us work the irregular warfare aspects.

And to the second part of your question, you are right. That is calling us to go out a get a different type of person to come into the science and engineering career force. We are working on that; we have a number of programs—engineering development, most notably the Nation Defense Education Program, where we are going out and actually paying people to get undergraduate and graduate degrees with a payback period to come in and work for a Department of Defense laboratory.

I have 134 people in the program right now. Think of it almost like a Reserve Officer Training Corps program for civilian scientists and engineers. This year we had over 1,000 people apply for roughly 100 scholarships, so we are getting good people to apply.

Mr. SMITH. We neglected to start the clock here, but I think we are pretty close to five minutes. Did you have anything else quickly? I wanted to get back to Mr. Kline.

Mrs. GILLIBRAND. I do, but I will wait my turn if we want to go around again.

Mr. SMITH. I had one more question myself, but if we get back to Mr. Kline—you had some follow up further that you wanted to do?

Mr. KLINE. Yes. And I will just limit it to the one area.

Let me reset the stage again. Each service, with each year—arguably each day or week—has got another system, another requirement, another need, another reliance on GPS, to the point where, hypothetically—I am going to walk into whatever classified areas—but hypothetically you may be developing one of the services a gun that has absolutely no ballistic capability. You shoot it, and if the GPS doesn't work the bullet doesn't land there. Hypothetically.

But the point is that we are really leaning on GPS. And so my question, perhaps to the DDR&E, perhaps to any of you: Are you confident that we are working, at any level in R&D—S&T on up—on making sure that we have either the correct protection or redundancy in that area? And I will just leave it at that and see what you have got.

Mr. SHAFFER. Yes, sir. I will give a brief answer and then turn it over to the other panel members.

There are a number of programs working in GPS. The one I would like to highlight is one started last year by the DDR&E in collaboration with the Navy and the Naval Research Laboratory. Now, it is a program element called I-Integrity Global Positioning System, and what it does is combine the signal—I can't get into any more detail than this—combine the signal from conventional GPS with commercial satellite communications to give a redundancy in case we lose some of the capacity of our GPS system.

So yes, we are looking at different types of methods and different technologies to protect that very critical aspect.

Admiral LANDAY. Yes. I would say from the Navy, you know, because of the history with submarines, we have historically looked at alternative ways to do navigation and position-keeping, and we continue to look at that. And as we see technology develop, even though there is right now a very heavy reliance on GPS, there is work going on in other ways that we can improve our accuracy not based on GPS, be that work that is going on on inertial measurement unit (IMU) that can be, you know, trunked down very small so that you can start putting those in, to different ways to fix your position to—just as we were able to go to GPS because we could more accurately measure time, does that allow us to fix our position in other ways, given that we know how to do that?

So I think clearly there is a large reliance on GPS right now, but there is also a very strong effort to say, "What else is there out there?" not only because of the potential threats to GPS, but also in some cases, GPS doesn't do what we want to do. Unmanned underwater vehicles are a great example of that. If I have to keep popping them up to get a GPS fix, we are kind of disadvantaging what they bring.

So there is a strong desire to look for alternatives while GPS remains the primary one as of right now.

Dr. TETHER. And what we have done—in fact, it is in that book that you held up, on page 17—is, one of the things with networks that we have today—these self-forming networks that basically are the basis of our whole future warfare, that people will be connected together and therefore have great situational awareness, but that these networks do it by themselves—the one thing that they all seem to have to have is a common time hack, and right now we use the GPS signal for time more than we do for location, in the network area.

So if you look on page 17, to try to overcome that vulnerability, we basically took an atomic clock—which is a big thing if you have ever seen one, it is the size of these tables here—and we put it on a chip. And it exists today. Again, this is, you know, started five, six years ago.

This is not science fiction. I mean, we were trying to get it down to one cubic centimeter; we are still working to get it down to one cubic centimeter using 30 milliwatts of power. We are about three times that in size and about three times that in power now.

But this is on a chip which has 1 second and 10,000 years accuracy. What this means—and it is going to the Single Channel Ground and Airborne Radio System (SINCGARS), by the way. The SINCGARS network, if you tried to turn off the radio to save batteries, the problem is that after a few hours if you tried to get back on the net it would take you a long time.

But SINCGARS is putting in even the larger version of the atomic clock because, quite frankly, they have got a lot of room to put it. And they will be able to turn that SINCGARS radio off, and then hours later turn it back on and instantly be back on the network because the time hack for the encryption will still be valid.

So we are working that problem that way with that technology. Now, the IMU stuff that Bill talked about is also true, and I think they are doing a good job on that.

Mr. KLINE. Okay. The clock is about to go red, and I am going to yield back, but I just want to say thanks.

I knew that people were working; I hope that we have got a—to Mr. Thornberry's point—sort of a coordinated effort here to make sure that we are covering these bases and we are not just going to turn around one day and radios won't talk, ships will be lost, you know, bullets don't go where we want them to and all that sort of thing. And it is a concern; I am glad to hear that you are on top of it, and for all things I will just say thanks.

I yield back.

Mr. SMITH. Thank you.

I want to follow up on the data management question, try to get a practical example of how this works and what we are trying to do in terms of dealing with it. You know, we gather a lot of information for intelligence purposes from a whole wide variety of different sources, which we don't have to get into. But basically it generates, you know, voice, pictures, data, you know, from, you know, Iraq, Afghanistan, a variety of other places as well.

So somewhere within, you know, the Pentagon, or perhaps within the CIA, all of this information is coming back, and there is a lot—a lot—of it. A staggering amount of it, as a matter of fact, if you were to take a look at it.

And we are looking for certain things in that data. Not just idly curious about everything; looking for, you know, high-value targets. You know, obviously we would like to see their smiling face hanging out at, you know, at a house somewhere, but certainly see them moving, you know, looking, you know, as we have talked about improvised explosive devices as their topographical information is coming back that is telling us a little bit about where they might be.

So all this stuff comes back, and, you know, you could probably come up with your statistic for, you know, your average computer person. Let us imagine that there is one person sitting somewhere, you know, and all this stuff is coming back to him. And it would take him, you know, 100,000 years to look through all of it—just 1 year's worth. What are the various technologies and approaches that we employ to try to, you know, sift through the meaningless data that is just open landscape, people going back and forth to markets who we don't care about, cell phone conversations between teenagers, all that stuff that we are not really interested in, to get down to the stuff we are interested in?

You know, avoiding getting into any classified stuff, but just roughly speaking, what do we do to try to synthesize that now, and then, you know, in Dr. Tether's area, you know, what are we trying to develop? What are the most promising technologies to get better at that? And any one of the services that wants to take a crack at that—Dr. Killion——

Dr. KILLION. Well, certainly one class of technologies that we are pursuing for various applications is Intelligent Agent Technology——

Mr. SMITH. Right.

Dr. KILLION [continuing]. Essentially something that is posted on your computer that is looking for specific aspects in the data and can prompt you when it finds something that you need to look at. We found a need for that in some change detection work that we had done, where it is hard to have an analyst look at a strip map from the day before and the one that you just took an hour ago, and compare and find all the little changes that may have occurred; whereas, if the computer can say, "There is a change here, here, and here"——

Mr. SMITH. Look at those three.

Dr. KILLION [continuing]. He can look at those, and he doesn't have to spend 12 hours poring through that strip map. He can do it in 10 minutes, perhaps. So that type of technology is certainly applicable in this domain, helps us identify where is the relevant portions of the data to look at, and then reduces the overload of the operator.

Mr. SMITH. And how good is that? How dependable are those intelligent agents out there? I mean, it is a hard metric to measure, I will grant you, but how confident are you that it is picking out the stuff that you need to see?

Dr. KILLION. I think it does a pretty good job, to be honest——

Mr. SMITH. Yes.

Dr. KILLION [continuing]. Mainly because it is tuned to the specific domain of interest.

Mr. SMITH. Right.

Dr. KILLION. What we have found—I went to graduate school in an era when they were talking about, artificial intelligence computers were going to be just as intelligent as people any day now, you know, and unfortunately that was quite some time ago, they are not there yet. But what has been demonstrated successful since that time are expert systems in specific domains, and that is essentially what an intelligent agent is—something that is tuned to that domain and can recognize those characteristics.

Mr. SMITH. And actually computers, based on what I have seen, are coming a lot closer to that day you mentioned than most of us would be comfortable with, as a matter of fact. And in terms of, you know—I guess one of the other questions is, basically it is also, I mean, the dependability of it, the usefulness of it is dependent upon the data, as always, that we put into it—the modeling when we decide to put in the intelligent agent, we decide what it is looking for.

So we have got to be, you know, clever about that; and that is probably, from what I hear you saying, is, you know, a good 80, 90 percent of the battle right there, is to have the intelligent agent know what it is looking for. And there is obvious limitations to that, because every once in a while something pops up that is interesting, that is important, that we had not planned to be looking for, and there is really not much you can do about that.

That helps me. And I am about out of time, and I know Ms. Gillibrand had a couple more questions that she wanted to follow up on. So I am done, and I will turn it over to Ms. Gillibrand for any follow-up that she had.

Mrs. GILLIBRAND. Thank you.

I just wanted to continue to pursue the line of questioning we were talking about. You said the response to the need to hire more engineers—because in your testimony you talk about the reduction in the number of PhDs in this country that are being developed. So in response, you are recruiting at an earlier year level, trying to cultivate these engineers and scientists earlier.

What else are you doing? Are you going to do anything about salaries or different facilities, different training? Are you looking at public-private partnerships in the meantime to have access to the greatest minds that may be in the private sector? Because I think just 150 people that you are recruiting now is probably not enough.

Mr. SHAFFER. Fair comment, and we are looking at a lot of different things. Right now we are trying to work our way through as we are implementing the National Security Personnel System and understanding the nuance of what you can and cannot do. But there is also a number of authorities out there in the personnel system that we have begun to take advantage of.

There are programs like Highly Qualified Expert, that allows us to go out and hire people, fairly quickly, at a higher salary structure rate. We continue to use the IPAs—Intergovernmental Personnel Act, I think is the full title—to go out and hire people, some of these areas that, coming in from a non-profit, not-for-profit, coming in and acting as a government person in those areas where we have a hard time meeting some of the salary structure.

So we have a number of IPAs scattered throughout the science and engineering infrastructure. We have, I think, a fairly effective—and it is a very interesting thing—we have a fairly effective internship program at each of these gentlemen's laboratories. And the reason I bring up the internship program: Scientists and engineers are strange people. I shouldn't say that, but scientists and engineers are——

Mrs. GILLIBRAND. Talented people.

Mr. SHAFFER [continuing]. Strange and talented. It is funny. Scientists and engineers are not just motivated by money. They are motivated by getting up in the morning and saying, "That is an interesting problem and I want to work there."

So if we can go out and reach out and bring in kids who are in, you know, universities and even high schools, as interns, and let them come in and see what the possibilities are, you can start to hook them. And I know that that has been very effective. We put some people—actually, some people have come to me—I have put some people over at Navy Research Laboratory because it is in D.C. The people come out of that loving what they are doing.

But we have to be very creative in a very competitive job market. I won't tell you, ma'am, that we have all the answers. We are looking at things. I would like to yield to some of my colleagues to——

Mr. JAGGERS. From the Air Force, I would like to address that. I think the Air Force is trying to lean forward in this area. Something——

Mrs. GILLIBRAND. And you are also doing the cyber security mission right now, aren't you?

Mr. JAGGERS. Yes, ma'am, a number of cyber activities. There has been a legacy of information technology investment up at Rome, in the Air Force Research Laboratory, that has taken on a new dimension, new flavor, on cyber network protection, network defense, network attack. I can't claim we have a completely comprehensive strategy right now, but I would like to highlight a few things that we are doing right now.

First of all, we are setting up cyber command as its own command. I think that is going to do a lot to institutionalize a workforce; right now there is no centralized place for these people to go. The carenpeding is in a number of different functional stovepipe areas, so this will put a cohesive wrapper around that workforce.

Civilians—we have been hiring them in through lab demo, lab demonstration programs. So they are a little bit easier to get to. The military—we are trying to understand the pipeline for the accessions that we have to create. We have an ongoing study with RAND right now to understand what that background—technical background—should be for those military officers.

The struggle here is, there is not a strong academic institution right now. Cybernetics, for example—there is no cybernetics degrees in the nation, and we need to focus on creating those and putting those in place in academia so those people that we assess into the military, and civilians, have that background.

I mentioned the $13 million that we have moved into the cyber—fighting our way through cyber attacks; I mentioned the $5 million that we have put into cyber defense, a cyber bot, to do defensive network protection.

But more importantly, what that does is it attracts that workforce that wants to do those exciting things. In fact, we were just talking on Sunday—I don't know if you saw a commercial on TV, but it was one of the first that the Air Force put out to entice young folks, military and civilian, to get into the cyber domain of the Air Force. And I thought that was very encouraging. We didn't see jets flying on the commercial—the 30-second spot—we saw people working cyber attack, and I thought that was pretty neat.

Mrs. GILLIBRAND. Thank you.

Dr. KILLION. And to reinforce what Terry is saying, real quickly, and Al mentioned: If you go out to the laboratories today—our laboratories—you will find a lot of younger people there than there were five years ago.

Mrs. GILLIBRAND. Great.

Dr. KILLION. People who have come in because they are interested in supporting this nation's security. They are intrigued by the opportunity to work in this area, and we provide an environment with unique tools and challenges, that they come in each day and have the opportunity to work on very interesting problems. Up at Aberdeen they can blow things up or try to keep things from being blown up, and elsewhere they work on the network.

Mrs. GILLIBRAND. Thank you.

Admiral LANDAY. And I would, again, just echo all that. I think from a science and technology—whether it is in cyber or anywhere—one advantage we have that the commercial folks don't have is we tend to still do a lot of good, basic research.

Mrs. GILLIBRAND. Right.

Admiral LANDAY. Industry tends to want to go more to applied, so you have a recruiting tool out there for young scientists to come, particularly at the research level, because we will let them go do research that is of interest to us at that basic and early applied level.

In the cyber area, again, I think we are all doing, you know, very similar things. The services are working through that. You know, our network com does the cyber defense pieces of it for the Navy and to the Navy networks. But our SSG, our strategic studies group, has taken the thinking of this a little bit further. They were chartered by the Chief of Naval Operations (CNO) last year to take a look at cyberspace—not cyber warfare, but the broader cyberspace—and how it is going to support, and what we need to do to support naval warfare and naval operations in the future. They had a lot of discussion about—even on the military side—a cyber-enabled sailor, and what that really means.

And so, beyond the subset of folks who are going to be skilled, you know, defenders or attackers within the network, there is a broader sense that there is a skill set that you are going to need to have the average sailor to have that is above, probably, where we are today. So I think there is a lot of thinking about this, and the tendency is on the defense piece of it, which I think is the nearest one to—I think there is also a lot of discussion that says, "What, really, does this domain start to enable us to do that maybe in the past we hadn't thought about?" More, kind of, ones and zeros and not cyberspace.

But I think there is a lot of good work going on in this area. Thank you.

Mrs. GILLIBRAND. Thank you. I am encouraged. Thank you.

Mr. SMITH. And I do think that is the great advantage we have in recruitment, back on the original part. You know, you are doing some fascinating things that simply cannot be done elsewhere. And like you said, Mr. Shaffer, your average scientific mind is attracted to that kind of thing, and I think that is the great pitch that we have.

I have nothing further. I wanted to see if Mr. Thornberry——

Mr. THORNBERRY. Mr. Chairman, I have a matter of—a question I want to direct to the Navy, but it will be in classified form, I am afraid, so I want to alert you that we will be getting that to you.

The only other thing I would like to do is to commend you for improving the I.Q. and the class of the room by starting off with a Texas Longhorn. [Laughter.]

But it does occur to me that it would certainly benefit me, and perhaps the subcommittee, if we could have periodic informal exchanges with JASONs about some of the trends that we need to be thinking about and focusing on. I think it would help us do our job.

And with that, I yield.

Mr. SMITH. I want to thank all of you for coming and testifying this morning, and for the great work that you do on the science and technology issues. And we look forward to working with you on all of those issues. Thanks for coming in. I appreciate your time.

We are adjourned.

[Whereupon, at 12:25 p.m., the subcommittee was adjourned.]

A P P E N D I X

MARCH 13, 2008

PREPARED STATEMENTS SUBMITTED FOR THE RECORD

MARCH 13, 2008

NOT FOR PUBLICATION UNTIL RELEASED BY THE SUBCOMMITTEE

Statement by

Dr. Roy Schwitters

Professor of Physics
The University of Texas at Austin
and
Chair, JASON Steering Committee

Submitted to the

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

March 13, 2008

NOT FOR PUBLICATION UNTIL RELEASED BY THE SUBCOMMITTEE

Mr. Chairman, Members of the Subcommittee, and staff:

I am pleased to discuss with you today some observations and suggestions for managing the prodigious quantities of data produced by new sensor systems increasingly being planned and deployed in national security applications. Advances in micro-electronics and related fabrication technologies enable new kinds of systems comprising very large numbers of high-performance sensors that offer the promise of truly revolutionary advances in tactical intelligence and other pressing national needs. Unfortunately, much of this potential is currently hampered by inadequate tools and methods for analyzing the data and communicating key information derived from it to users in timely ways. The intelligence value of data provided by the new sensors could, most certainly, be enhanced further by developing new ways to combine information from diverse types of sensors and other data sources. The scientific community faces similar data-handling issues and has achieved notable successes in building and using large sensor systems.

The "Data-glut" Problem

My comments are drawn from interactions with technical experts on new sensor systems and from discussions with my colleagues in JASON, a group of research scientists and engineers, largely from academia, who study technical problems related to national security for various agencies of the US government. In recent years, JASON has encountered the "data-glut" problem of large sensor systems in many forms, from tactical approaches to help counter the IEDs aimed at our troops in Iraq to understanding test results from prototypes of advanced sensor systems. Several of us deal with similar problems in our own scientific research.

The data-glut problem comes about because of the tremendous capabilities inherent in relatively inexpensive modern sensors when combined into large networks. In the commercial world we see it through the ever increasing capacities for data storage that we buy for our laptops and iPods to be able to store all those family photos enabled by our cell-phones, the movies we want to watch, and music we like to listen to. Fortunately, the capabilities of commercial networks and cost-effectiveness of data storage hardware have been able to keep up with demand for the new capabilities.

When it comes to tactical surveillance systems, however, the demands are much higher. Our troops and intelligence analysts need accurate, timely and relevant information. For example, a single modern aerial reconnaissance system may use 100 mega- (M) pixel cameras operating at several frames per second. This can generate 10 to 100 terabytes (TB) of data per day. It can be stored on 10 to 100 modern disk drives, but transporting and analyzing such data can take weeks. By then the intelligence value may well be gone. For reference, I have been told that the total data communicated from theater to CONUS now is estimated to be about 270 TB/year. The aerial reconnaissance data from just one platform would totally swamp those channels.

Merely increasing the capacity of our data channels won't do the job—flying disks on airplanes to an analysis center actually provides good bandwidth. However, the analysis must keep up with the flow of data to avoid pileup, not unlike that encountered by Lucy and her neighbor Ethel in the famous chocolate factory episode of *I Love Lucy*. Thus, the full pipeline for transporting data from the sensors through analysis to information products must be considered in the design of new systems.

Beyond quantity, it is the *quality* of the information derived from new sensors that is of paramount importance if we are to succeed against our determined and technically savvy adversaries. Simple photos and videos are not adequate. For example, we want to know if an IED has been planted along a certain stretch of road *before* driving on it. Then we want to know who planted the IED, who built it, and who financed the operation.

To answer these complex questions, capabilities of data analysis tools need continuous improvements commensurate with the advances in sensor technology. There are issues with the tools we have now. For example, "compressing" video data can irretrievably lose information that might be critical to answering certain questions. On the other hand, lossless compression algorithms exist, for example, change-detection. Extracting useful intelligence information from the huge background of ordinary activity is a most difficult challenge; we need tools that focus on abnormal activity or changes in the normal environment. Automatically linking visual information with other sources of data is problematic.

Examples from Scientific Research

Are there examples of sensor systems where the data-glut problem is being well-managed with lessons that might be applicable to national security needs? Yes, there are good ones, going back to before the personal computing revolution. I will briefly describe two current cases, one taken from astronomy where sensor development and associated analysis are revolutionizing our understanding of the cosmos, and the second taken from my field of high energy physics where extraordinary new detectors are about to come online at the CERN Large Hadron Collider in the quest to learn more about the smallest particles of matter and energy in our universe.

The first prototype telescope of the Panoramic Survey Telescope & Rapid Response System (Pan-STARRS) is operating in Hawaii. Pan-STARRS is designed to view the entire visible sky several times a month finding anything—including objects 16 million times fainter than what can be seen by human eyes—that moves in unexpected ways. By today's standards, it has a conventional mirror and uses much commercial, off-the-shelf computing and communications hardware, but its camera is special: the light sensor has 1.4 billion pixels, about 100 times more than the best personal digital cameras available today. Pan-STARRS records *and analyzes* 2 TB of data every day; several peta-bytes (PB or 1000 TB) will be archived over its scientific life. Sophisticated, quantitative analyses take place on the full pipeline of data using conventional computers and open-source software, adapted to its scientific needs.

Two remarkable particle detectors, called Atlas and CMS (and two other slightly smaller relatives) are nearing completion at CERN near Geneva, Switzerland to collect data from the Large Hadron Collider when it begins operating later this year. Their purpose is to study the conditions that existed in our universe 1 nano-second after the big-bang. Atlas and CMS examine the debris of extremely high-energy proton-proton collisions in exquisite detail. They each are the size of 5-story buildings, consisting of approximately 100 M sensors that track and analyze the hundreds of particles all traveling at nearly the speed of light created in every proton-proton collision. Up to 300 million collisions take place each second, resulting in about 10 TB of data recorded daily. Out of all those collisions taking place each second, the events most sought after by the scientific teams that built the detectors are expected to occur only once a day or less.

The sizes and intrinsic data rates encountered by Pan-STARRS, Atlas, and CMS are greater than those contemplated for tactical surveillance systems. They and other examples from the scientific community share important attributes which are relevant national security systems:

1) The scientific observing systems must separate very rare events with high efficiency from large backgrounds of ordinary activity. It is not practical to do so by human analysts viewing images; automated, quantitative forms of image analysis were developed to do this. Telescope plates and bubble chamber photos are relics of the past. The major activity of the scientific teams is developing software tools for data analysis, including accurate characterization of the performance of the detector system.
2) The *quantity* of data to be handled is strictly controlled to maintain a viable analysis pipeline with priorities established by the science teams. Generally, multi-level approaches are taken whereby automated decisions to retain information are made commensurate with the data rate, hardware, and software capabilities. Developing the data "trigger" systems and monitoring their effectiveness is another area of major investment by the scientific teams.
3) Effective scientific teams comprise highly integrated groups of hardware builders, software developers, and data analysts. Most are international in character. Open lines of communications within and outside the team are essential, while quality control of the scientific product is strictly controlled internally and outside thróugh peer review.

Observations and Conclusions

What I have been describing—the interplay of hardware capabilities and user needs to achieve useful systems—is the traditional business of systems engineers. The potential afforded by the large new sensor systems is too important to ignore, but their large data rates and the need to extract extremely rare pieces of information from the data present difficult challenges for systems-engineering. There are no general theories of sensor-fusion or data-compression that can be applied to every problem. Much exploratory work is needed in any new system to discover what kinds of data analysis approaches work and what don't. We strongly urge the defense and intelligence communities responsible for developing new sensor systems to take pages from the "big-science" playbook as they pursue these important systems. Specifically, we would like to see:

1) Establishment of integrated teams of users and builders—analysts, software developers, hardware experts—to be brought into data-management and analysis from the beginning of new projects through exploitation of information in operating programs.
2) Elevated support for and recognition of the importance of quantitative data analysis in tactical and strategic surveillance systems to maximize the useful information that can be obtained from deployed systems. This will involve nurturing a community of data analysts charged to develop new and better ways to extract information of value to end-users from sensor systems and other data sources.
3) Commitment to use some fraction of existing tactical intelligence resources, prototype sensor collection exercises, and other such opportunities to educate the larger sensor and analyst communities and to provide real-world test problems for exploratory data analysis.

In my judgment, the technical challenges presented by large sensor systems needed by the tactical intelligence community would attract participation by academic scientists and engineers. These communities bring experience, new ideas, and, most important, students to these interesting technical problems. For example, exercises involving collection of data from diverse kinds of prototype sensors, not directly related to classified work, could provide data where academic researchers can make a real impact. New people, trained in exploiting large data sets which flow from the new sensor systems will be needed to design, build, and operate the future systems we count on. I know of no source for these people other than the research community.

The open lines of communications essential to building Pan-STARRS, Atlas, CMS, and dozens of other major scientific instruments present a particular challenge to national security efforts which must operate under classification rules. For there to be comparable success with new national technical systems involving such elaborate interplay of sensors, communications, computation, and analysis, it will be necessary to develop new modes of communication within the classified community and with outside researchers. There are ways for this to work, but it will require effort and commitment on the part of national leadership, congress, and the classified community. It is most important, however, that the relevant teams of professionals within the appropriate agencies be empowered to solve their own data-glut problems and to find new ways to extract from these systems and other sources the information they need. Experience gained from the scientific community could be a big help to them. It is important to recall that the world-wide-web was invented at CERN a generation ago to handle the problems of data-glut and team communications in experimental high energy physics.

Thank you for this opportunity to address the Subcommittee. I shall be pleased to answer your questions.

HOLD UNTIL RELEASED
BY THE COMMITTEE

STATEMENT TESTIMONY OF

MR. ALAN R. SHAFFER
PRINCIPAL DEPUTY, DEFENSE RESEARCH AND ENGINEERING

BEFORE THE UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON ARMED SERVICES

SUBCOMMITTEE ON TERRORISM, UNCONVENTIONAL THREATS
AND CAPABILITIES

March 13, 2008

Mr. Chairman, distinguished members of the Subcommittee, thank you for the opportunity to appear before you today to describe the Department of Defense Science and Technology (S&T) program. I am honored to represent the great accomplishments of the thousands of dedicated professionals who work in the DoD S&T enterprise. Once again, this is an exciting year to discuss the merits and promise of the DoD S&T program—a program that has a long history of developing technologies that led to the superior operational capabilities employed and enjoyed by the men and women of our armed forces today. While the S&T program continues to deliver superior capabilities, the challenges we face in the future drive us to evolve and expand this program.

INTRODUCTION

The evolution of the national security threat, as outlined in the 2006 Quadrennial Defense Review, coupled with the emergence of an agile and global technology development base has led to a changing of the technology landscape for the DoD. When this is coupled with the emergence of a commercial technology base that paces military applications in some key areas, the result is an emerging set of challenges for the Department's S&T program. Over the past several years, Congress has recognized this evolving set of challenges, and consistently supported the DoD S&T budget requests. For that, we thank you. In response to the evolving need, the Department has experienced a decade-long growth in the budget request for the S&T program, culminating in this year's budget request of $11.5 billion dollars—a figure that represents a 4% real growth compared to the FY 2008 President's Budget Request. Of note, the FY 2009 budget request is also one of the highest S&T budget requests, in constant year dollars, since the inception of the McNamara budget process of the early 1960's. In fact, the seven highest DoD S&T budget requests have come in the past seven years.

Perhaps more noteworthy in this year's budget request is the increase in Basic Research. In the FY 2009 budget request, Basic Research grows to $1.7 billion; which is a 16% increase compared to FY 2008. This increase in Basic Research will be more fully discussed later, but the growth of both S&T and Basic Research are indicative of the continued commitment the Department is making to developing the technologies and capabilities to support the future operational needs of the men and women in uniform. Over the past several years, we have begun to reshape the S&T investment of the DoD to increase "non-kinetic[2]"

[2] The term "non-kinetic" was used in the 2006 Quadrennial Defense Review to describe those capabilities that do not have mass. For instance, non-kinetic capabilities include information and data, decision making, human-system interface, biometrics technology and so forth. "Kinetic" capabilities on the other hand, are platforms (ships, tanks, planes and weapons).

capabilities, and we are starting to see some real payoff in terms of capabilities being delivered to our warfighters. In addition, the fact that Congress has also given us flexibility in several programs to develop and apply technologies rapidly has allowed the DoD to field advancing non-kinetic capabilities more quickly. For example, one of the projects from the Quick Reaction Special Program led to an expanded role of the S&T community in defense biometrics and forensics.

While the DoD S&T program is currently well positioned to support the future force, there is still much to accomplish. The DoD S&T program must simultaneously develop technologies to improve conventional warfighting systems while addressing emerging technologies developed both in the DoD laboratories and commercially, and integrating these emerging technologies into a potential solution that provides greater capability to our forces. As an example, this trend is apparent in the mission area of persistent surveillance, where the amount of data available from sensors and information systems is growing from terabytes to exabytes and zettabytes in the near future. This "explosion" of information available to the warfighter is one prime area that needs the integration of technology developed in both the Department and commercially to support the warfighter. Simply, the ability to handle very large data sets in the future will be a challenge for the DoD.

THE NEED FOR DEFENSE SCIENCE AND TECHNOLOGY

Both the President and Secretary of Defense have recently highlighted the need to enhance science and technology, particularly in the physical sciences. For instance, in highlighting the American Competitiveness Initiative[3] the 2008 State of the Union address, President George W. Bush said:

> *"To keep America competitive into the future, we must trust in the skill of our scientists and engineers and empower them to pursue the breakthroughs of tomorrow... I ask Congress to double federal support for critical basic research in the physical sciences and ensure America remains the most dynamic nation on Earth.."*

Similarly, in February 2008, during his budget posture hearing, the Secretary of Defense Robert Gates said:

> *"As changes in this century's threat environment create strategic challenges – irregular warfare, weapons of mass destruction, disruptive technologies – this request places greater emphasis on*

[3] The American Competitive Initiative agencies are the National Science Foundation, National Institute of Science and Technology, and Department of Energy

basic research, which in recent years has not kept pace with other parts of the budget."

It is important to address reasons why both the President and Secretary highlighted science and technology and in particular, basic research, as key to the future. Simply, the globalization and application of technology provides more opportunities and challenges to the United States and subsequently to the DoD. In a recent essay written by Dr. Norman R. Augustine for the National Academy of Sciences entitled "Is America Falling off the Flat Earth?", Dr. Augustine cites a number of indicators highlighting the overall decline in the science and engineering posture of the United States. Among the indicators Dr. Augustine cites are:

- In 2004, Federal Funding of research in the physical sciences as a fraction of GDP was 54% less than in 1970. In engineering, it was 51% less. This decline in overall federal funding is amplified in the DoD, since the percentage of overall federal funding of basic research from the DoD has declined almost 8% over the same period.

- By the end of 2007, China and India will account for 31% of the global R&D staff, up from 19% as recently as 2004.

- The share of US post-doctoral scientists and engineers who are temporary residents has grown from 37% to 59% in two decades.

These are just several examples of the indicators of the decline in S&T, but they support an increase to the funding request for basic research in the Department's FY 2009 budget request. But these indicators, by themselves, do not constitute a need to increase DoD S&T funding.

Challenges facing the DoD have several additional complicating dimensions, some of which should affect S&T investment. As the United States continues to evolve in the Global War on Terror, the Department needs to develop an increased set of capabilities in disciplines not normally associated with the DoD. This need was highlighted in the 2006 Quadrennial Defense Review (QDR), a document that formed the foundation of the 2007 Department of Defense Research and Engineering Strategic Plan. The DoD has expanded our S&T investment in such areas as: Biometrics; Human, Social, Culture and Behavior Modeling; Locating, Tagging and Tracking; Networks; Persistent Surveillance; Cyber Protection, and other "non-traditional" areas. While there are a number of expanded mission areas the Department's S&T program should address, it is important to note the need to also conduct research to improve conventional weapons has not gone away, so a prudent mixture is needed.

Another aspect of the S&T program that is significant when considering funding is the expanded role of the DoD technologist to impact acquisition programs. This role is articulated in the new vision provided by the Under Secretary of Defense for Acquisition, Technology and Logistics. This vision is to "Drive Capability to Defeat Any Adversary on Any Battlefield." The key word for the S&T community is "drive." To drive the capability, the acquisition team, which includes S&T members, has to strive for agility and a sense of urgency. As part of this journey, the S&T team has expanded contact with the acquisition community through the use of technology readiness assessments—a process that allows the Department to insert matured technology into acquisition programs at the right time to minimize risk. By more closely managing technology maturity, the DoD should be able to accelerate fielding of systems. Additionally, we have revamped the cross-departmental planning process called "Reliance 21" and expanded our outreach to develop new scientists and engineers to work on DoD challenges. All of these tasks expand the requirements on the S&T program, and provide additional rationale to enhance S&T investment.

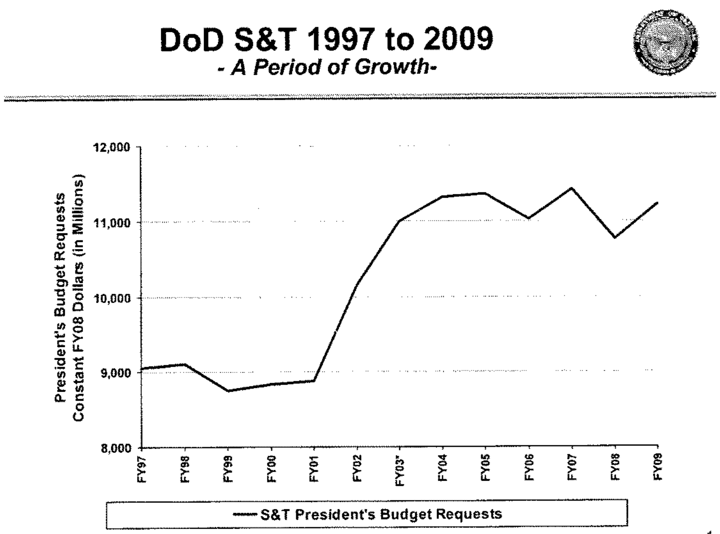
Thus, there is a situation where there is increased competition in the generation of new ideas and capabilities to the DoD, while at the same time the DoD S&T workforce is, of necessity, investigating a broader range of technical areas and simultaneously increasing the interaction with the acquisition and operational communities. This convergence of factors supports an increase in the President's Budget Request for S&T.

FY 2009 SCIENCE AND TECHNOLOGY BUDGET REQUEST – COMPONENT HIGHLIGHTS

As mentioned previously, the FY 2009 President's Budget Request of $11.5 billion represents a strong corporate commitment to investment in S&T, despite difficult budgetary demands from the Global War on Terror and growing non-discretionary departmental bills. The FY 2009 request is over four percent higher than the FY 2008 request, in real terms. From FY 2002 to 2008 the S&T budget has grown 10.6% (in real terms), or nearly two percent real growth per year. Figure 1 shows the President Budget Request, in constant dollars from 1997 to 2009 – clearly the DoD has been increasing emphasis on S&T.

Comparison of DoD Research and Engineering Requests
(President's Budget – Total Obligation Authority)

Then Year Dollars (in millions)	FY 2008 Request	FY 2009 Request
Basic Research	1,428	1,699
Applied Research	4,357	4,245
Advanced Technology Development	4,987	5,532
Total DoD Science and Technology	**10,772**	**11,475**
Advanced Component Development and Prototypes	15,662	15,774
Total DoD Research and Engineering	**26,434**	**27,249**



In FY 2009, the Department made a conscious decision to increase investment in the Services relative to the Agencies and Office of the Secretary of Defense. Consequently in this year's budget request, the Services once again account for more than half of our total S&T investment. Over the next several paragraphs, we will highlight the more significant aspects to the FY 2009 budget request across the DoD.

Army S&T Request
(President's Budget – Total Obligation Authority)

Then Year Dollars (in millions)	FY 2008 Request	FY 2009 Request
Basic Research	306	379
Applied Research	686	724
Advanced Technology Development	736	739
Total Army Science and Technology	**1,728**	**1,842**

The Army's Science and Technology (S&T) investments are shaped to pursue technologies that will enable the future force while simultaneously seizing opportunities to enhance the current force. The S&T program retains flexibility to be responsive to unforeseen needs. Major elements of the Army's FY 2009 S&T budget include:

- Basic Research ($379 million), the largest S&T investment, to fund advances in scientific knowledge with dramatic potential for the Army to achieve superior land warfighting capabilities. Army basic research continues to pursue network science, neuroscience, biotechnology, immersive technology, quantum information science, nanotechnology, and autonomous systems. The Army has also increased funding to establish research initiatives in human, social, cultural, and behavioral modeling; modeling and analysis of complex, multi-scale networks; and neuro-ergonomics.

- Force Protection technologies ($370 million) focused on providing active and passive protection to increase survivability of Soldier, rotorcraft, and ground vehicles. This includes the technology to defeat rockets, artillery rounds and mortars; detect and neutralize improvised explosive devices (IEDs)/mines; and protect against traditional threats to tactical and combat vehicles. Force protection technology continues to focus on protection technology suites that maximize protection through the synergy of effects such as increased performance armor, directed energy weapons, and electronic warfare technologies. Increased funding is provided for initiatives in advanced armor and materials to provide reactive and electromagnetic armor solutions against emerging and future kinetic energy and chemical energy threats.

- Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) technologies ($294 million) to enable networked surveillance and knowledge systems for collaborative real time mission planning, on-the-move operations and networked lethality. These technologies include secure, mobile, ad-hoc networks for sustained high tempo full spectrum operations; infrared (IR) technologies for extended range threat detection and identification; and airborne imaging/moving target detection radars. This request also includes an increase in FY 2009 and 2010 to complete and transition the successful foliage penetration (FOPEN) Advanced Concept Technology Demonstration (ACTD) in support of USSOUTHCOM.

- Lethality technologies ($161 million) including development of next generation explosives and reactive materials to enable controlled lethality warheads to provide scalable effects that range from less-than-lethal to extremely lethal in a single munition; novel recoil attenuation techniques for large caliber weapons systems that reduce gun weight and improve performance; next generation seekers and warheads for affordable missile and gun systems such as the Non-Line-of-Sight Launch System; and electromagnetic gun research.

- Medical technologies ($140 million) that improve protection, treatment and life-saving interventions for Soldiers. The medical technology efforts focus on three major areas: combat casualty care (including the mitigation and treatment of blast injury and tissue regeneration efforts); infectious disease (diagnosis, treatment and preventatives), and operational medicine (the development of treatments and practices for Soldiers in extreme environments such as high altitude or sleep deprivation.)

- Soldier System technologies ($135 million) including advanced body armor, disposable and rechargeable electric power, Soldier-level networked communications and situational awareness, the development of techniques for selecting effective leaders and strategies for Soldier retention.

- Logistics technologies ($92 million) including precision airdrop; system prognostics and diagnostics for operational readiness; and hybrid electric drive train technologies to reduce logistics demand.

- Rotorcraft technologies ($72 million) that focus on achieving improved rotorcraft performance, increased operational readiness and lower operations and sustainment costs.

- Air and Ground Unmanned Systems technologies ($54 million) to reduce risks to Soldiers by extending reach and endurance through near autonomous capabilities for unmanned systems.

- Advanced Simulation ($37 million) for immersive mission rehearsal and advanced technology emulation and adaptive learning capabilities.

Navy (DoN) S&T Request

(President's Budget – Total Obligation Authority)

Then Year Dollars (in millions)	FY 2008 Request	FY 2009 Request
Basic Research	467	528
Applied Research	678	633
Advanced Technology Development	522	679
Total DON Science and Technology	**1,667**	**1,840**

The Department of the Navy (DON) has defined 13 Naval S&T focus areas. Within these areas are the traditional fleet technologies, but the Navy has also established focus areas in power and energy, maritime domain awareness (surveillance coupled with information processing), and assured access to hold an adversary at risk. Major elements of the Navy's FY 2009 S&T budget request include:

- Discovery and Invention (D&I) ($773 million) consists of basic research and the early stages of applied research. D&I is the seed corn for future naval technologies and systems. It provides technology options, maintains critical U.S. S&T capacity, and develops the next generation of the S&T workforce. The D&I portfolio, by design, has a broad focus, and programs are selected based on Naval relevance and technology opportunity. An important aspect of the Office of Naval Research's (ONR) D&I is the investment in unique Naval disciplines (e.g., ocean acoustics, underwater weapons, underwater medicine, naval engineering), and those areas that could benefit expeditionary warfare. To avoid sub-critical DON investment, D&I investments leverage other Service, governmental department, industry, international, and general research community investments.

- Acquisition Enablers ($589 million) center on Future Naval Capabilities (FNCs). These work to mature technology into requirements-driven, transition-oriented products in the late stages of applied research and advanced technology development. FNCs provide enabling capabilities to fill gaps in Department of Navy acquisition efforts.

- Leap-Ahead Innovations ($203 million) "Innovative Naval Prototypes" and "Swamp Works" projects comprise the bulk of this S&T investment. These are technology investments that are potentially "game changing" or "disruptive" in nature.

The Department of the Navy's S&T investment also supports the High Integrity GPS program ($63 million), a project that has the potential to be truly revolutionary for all Components. This project is funded in the Common Picture Advanced Technology.

Air Force S&T Request
(President's Budget – Total Obligation Authority)

Then Year Dollars (in millions)	FY 2008 Request	FY 2009 Request
Basic Research	375	452
Applied Research	1,011	1,044
Advanced Technology Development	577	578
Total Air Force Science and Technology	**1,964**	**2,075**

The Air Force has refined the focus of their S&T program to anticipate, find, fix, track, engage, assess – anything, anytime, anywhere. Highlights of the FY 2009 Air Force budget request include:

- Foundational Sciences ($442 million) This investment is comprised of basic research. Increased investment in fundamental basic research to include the University Research Initiative with emphasis in the areas to defeat speed of light weapons, information warfare/information assurance (quantum computing/encryption), networking, improved decision making technology, autonomous systems (bio-inspired, swarming, etc.,) and nanotechnology/nanosensors.

- Weapon Systems ($208 million) – Increased emphasis in offensive and defensive Directed Energy S&T, including eye safety and thermal management technology, and solid state lasers and high power microwaves that could enable speed of light attack with extremely high precision and minimal collateral damage. The AF also continues to develop advanced conventional weapons.

- Anticipate, Protect Against, and Track Enemy Actions ($435 million) – Increased emphasis in areas to better anticipate, protect against, and track enemy actions, anywhere, anytime, to include decision making tools and techniques that understand political, military, economic, social, information, and infrastructure relationships, offensive and defensive cyber operations, and multi-layered sensing architectures providing persistent intelligence, surveillance, and reconnaissance capabilities.

- Space ($223 million) – Increased emphasis in Space S&T in the areas of Space Situational Awareness and Defensive Counter Space could enable better awareness of potential spacecraft threats and protection from those threats.

- Propulsion, Structures and Energy ($557 million) – Increased emphasis in revolutionary propulsion S&T in the area of Adaptive Versatile Engine Technology (ADVENT) that could enable development of energy efficient, multi-design point engines pervasive to multiple aircraft platforms. The Air Force also increased emphasis in the area of aircraft power and thermal management, addressing operational limitation concerns about the growing thermal load on fielded and pipeline aircraft.

- Materials and Manufacturing ($199 million) – Increased emphasis in metamaterials technology development, addressed an industrial base issue involving Lithium Ion batteries, and realigned Manufacturing Technology (ManTech) into the S&T portfolio. The AF ManTech program is now better focused on generic and pervasive long-term manufacturing technologies and near-term processes with the main objectives to reduce costs in acquisition and sustainment systems, reduce cycle and delivery times, and reduce risk to fielding of new capabilities.

DARPA S&T Request

(President's Budget – Total Obligation Authority)

Then Year Dollars (in millions)	FY 2008 Request	FY 2009 Request
Basic Research	153	196
Applied Research	1,403	1,334
Advanced Technology Development	1,477	1,625
Total DARPA Science and Technology	**3,033**	**3,155**

The FY 2009 budget requests $3.2 billion to continue DARPA's basic, applied, and advanced technology programs. Basic Research is funded at $196 million in FY 2009 to continue projects in biology, electronics, materials and information sciences. DARPA will continue investments in Space ($417 million); Networks ($317 million); manned and unmanned ground, sea, and air Advanced Platforms ($421 million); and Cognitive Computing Systems ($146 million). DARPA also is continuing investment in hypersonics through the new Blackswift program which is jointly funded by the Air Force. DARPA also is expanding support to the President's Comprehensive National Cyber Security Initiative through an increased investment of $50 million.

DTRA S&T Request
(President's Budget – Total Obligation Authority)

Then Year Dollars (in millions)	FY 2008 Request	FY 2009 Request
Basic Research	5	18
Applied Research	182	211
Advanced Technology Development	213	211
Total DTRA Science and Technology	**401**	**440**

The Defense Threat Reduction Agency's (DTRA) Basic Research Program is conducting research to benefit WMD-related defense missions and improve Agency knowledge of other research efforts of potential benefit to DTRA non-proliferation, counter-proliferation and consequence management efforts. To complement the basic research, DTRA has taken steps within its Applied Research budget activity to develop a strong threat reduction technology base and provide a foundation for transformational activities within the counter-WMD arena through enhanced efforts within its Detection Technology, Advanced Energetics & Counter WMD Weapons, Nuclear & Radiological Effects programs.

- Detection Technology – Enables the detection, identification, tracking, tagging, location, monitoring and interdiction of nuclear and radiological weapons, components or materials.

- Nuclear Forensics - Develop and implement an accurate, rapid and reliable global capability to collect/analyze post-detonation prompt data and ground debris from a nuclear or radiological event.

- Advanced Energetics & Counter WMD Weapons – Enables the development and/or maturing of technologies supporting defeat of WMD targets (including facilities with chemical, biological, or nuclear (CBN) agents) while minimizing collateral damage and release of those agents when using air, land and sea assets brought to the theater by the warfighters.

- Nuclear & Radiological Effects – Enable the development of nuclear and radiological assessment modeling tools and the conduct of various analyses support and/or development efforts.

DTRA continues its efforts in restructuring its Advanced Technology Development investment portfolio to support the Quadrennial Defense Review Transformational Goals and to better align its portfolio with requirements and initiatives supporting combating WMD. Increased emphasis is occurring within the Counter-terrorism Technologies, Detection Technology, and Target Assessment Technologies programs.

- Counter-terrorism Technologies – Enables (1) the identification, defeat, containment, and mitigation of WMD-capable IEDs; and (2) Special Operation Forces (SOF) capabilities to detect, interdict, neutralize and destroy CBN production, storage and weaponization facilities.

- Target Assessment Technologies – Provides enabling technology for the Intelligence Community and COCOMS to find and characterize WMD targets, including those protected in hard and deeply buried facilities, to support full dimensional defeat operations.

EMERGENT AND NON-KINETIC PROGRAM INCREASES – DDR&E FOCUS AREAS

The FY 2009 S&T request continues the realignment to address new and emerging capabilities outlined in the 2006 QDR. The DoD began this realignment in FY 2008 and over the past two years has realigned roughly $3 billion in S&T investment planned over the future year defense program. Most, but not all of these increases were made to the Office of the Secretary of Defense programs. These realignments resulted in both new FY 2008 start programs and enhancements to existing programs. Highlights of some of the more significant of these efforts follow:

Biometrics S&T. The Department continues to increase the investment, in Biometrics S&T, following the program initiation in FY 2008. The biometrics office is working to advance capabilities to identify anonymous individuals using biometric markers, such as fingerprints, DNA, and so forth. The focus of the biometrics program seeks to improve the quality of biometrically derived information for the purpose of identifying and classifying individuals. It is vital that unknown persons be quickly and accurately characterized as "friend", "enemy" or "neutral" in all military environments to enable tactical, intelligence, and management decisions consistent with law, policy, and rules of engagement. The DoD Biometrics S&T program leverages heavily and co-develops the work in biometrics of other government agencies. By the end of 2009, the biometrics investment should deliver several key biometric products to include:

- DoD Biometrics Science and Technology Strategy and Roadmap
- Modeling tool for biometric systems architecture and decision support
- Prototypical biometric collection systems for demonstration and experimentation
- Prototypical forensic collection, processing, exploitation systems for demonstration and experimentation
- Data packages and white papers on standards and algorithm development

Human, Social and Culture Behavior Modeling. The Human, Social and Culture Behavior (HSCB) Modeling program is an integrated program that began in FY 2008, and continues with FY 2009 investment in specific programs in applied research, advanced technology development and advanced capability development and prototyping. The HSCB program seeks to develop and deliver models to help the US warfighters understand different cultures, social norms and behavioral responses. This collection of HSCB programs support all phases of military operations from full scale warfare to insurgency to security, stabilization, and reconstruction operations. The programs seek to develop software models and analytic approaches that provide insight and understanding for decision support programs of record, intelligence analysis tools and training simulation and gaming systems. The program will develop validated human terrain forecasting capabilities that can be generalized across user communities and can scale vertically from tactical to strategic levels.

The FY 2008 planned transitions from the program are an initial HSCB data model that seeks to support computational socio-cultural models that could be used in operational level planning. Initial cultural mapping capability will transition into the Distributed Common Ground Station - Army software and the delivery of a Pacific Command, Special Operations (SOCPAC) strategic planning tool. With the FY 2009 budget request, we anticipate up to six specific models, analysis or training products to be delivered in the fiscal year.

Persistent Wide-Area ISR. Over the past two years, the Office of the Director of Defense Research and Engineering (ODDR&E) has initiated several programs to accelerate the development and delivery of persistent surveillance. The first of these is the Synthetic Aperture Radar Coherent Change Detection (SAR CCD), which enables the tactical user to detect changes in terrain due to human activity by comparing multiple Synthetic Aperture Radar (SAR) images of the same area—separated by time. Synthetic Aperture Radars are largely unaffected by clouds, and measure very accurately the surface height and smoothness of a feature. Disturbed ground has a different reflective signature than does undisturbed ground. Using this attribute, the SAR CCD capability enhances the warfighter's ability to conduct persistent surveillance relative to multiple missions including special operations, detection of movement across borders, over the horizon, troop/vehicle movement, construction activity, and natural disaster monitoring (volcanic activity, fault lines). The goal of the SAR CCD effort is to deliver this capability, in a package that could fit on a small UAV, to the end user for $500K per platform.

Current operations have demonstrated the need for a robust infrastructure to support intelligence, surveillance and reconnaissance (ISR), to include strengthening the data storage, transmission and analysis tool capabilities to deal with very large data sets. In 2007, the ODDR&E initiated project Bluegrass to collect large multi-sensor data sets (including Electro-Optical and radar) with ground truth. This data set is being made available to qualified users to support the development of data analysis tools. The ODDR&E is working with the Under Secretary of Defense for Intelligence and the Joint Persistent ISR office of National Geospatial Imagery Agency to develop a set of challenge problems based on Bluegrass exercise data. The challenge problem will help identify focus areas and enhance future capabilities. It is interesting to note the JASONs advisory group recommended in January 2008, that the DoD make use of this data set to address the challenge of handling very large data sets – work that the Department has already begun.

Currently, the Joint Capability Technology Demonstration office within DDR&E is rapidly prototyping several potential solutions that could be game changers in the area of persistent surveillance. The first is a liquid hydrogen powered UAV that can stay aloft for days to weeks and carry a large ISR payload. This demonstration will carry a potential payload to allow long duration persistent surveillance. The same office is also demonstrating a solar electric powered UAV for small payloads that have the potential to be airborne for a month or longer. Airship technology is also an attractive alternative and we are prototyping an unmanned airship that can station-keep to provide extended-dwell area surveillance. To support DoD Homeland Defense and Homeland Security, this office is examining approaches that will improve over-the–horizon (OTH) radars for long range maritime and air tracking.

Finally, the ODDR&E is prototyping the use of such new capabilities as hyper-spectral imagers to determine unique attributes of terrain. Some of these prototypes are being used to deliver products supporting the GWOT. For example, this year, we organized a mission for the US State Department to map the natural resources of Afghanistan. This mission (referred to as Halo Falcon) was undertaken at the request of the Afghanistan Government, and used a prototype DoD Hyperspectral Sensor on the NASA owned WB-57 high altitude test aircraft. This project should permit the identification of natural resources and are important to the future economic well being of Afghanistan. These products are in the process of being delivered to the Afghanistan Government by the State Department.

Tagging, Tracking, and Locating. Tagging, tracking, and locating (TTL) is another important set capability enabled by a set of programs and functions sponsored by the ODDR&E, and is used in prosecuting the Global War on Terror. The U.S. Special Operations Command (USSOCOM) has placed TTL at the top of its priority list for technology enhancements, and the DDR&E, in cooperation with the Commander, USSOCOM has increased S&T funding in FY 2008 and the FY 2009 budget request.

The increased budget request for this capability has been placed in Program Elements at USSOCOM and in the US Army, with oversight by the USSOCOM Acquisition Executive and Deputy Under Secretary of Defense (Science and Technology). Nineteen new projects have been initiated in FY 2008 at all levels of S&T maturity. These projects emphasize technologies to reduce the size of tagging and tracking devices and to provide for new and better methods to deploy and monitor them. While much of the specifics of this work is classified, the potential near an far term pay off of this S&T effort to the GWOT is quite large.

Networks. In FY 2008, the ODDR&E started a new program in Networked Communications Capability. This program focuses on exploiting and improving the existing and planned DoD wireless communications networks used by our soldiers in Iraq, Afghanistan and around the world. The network program offers an example of the convergence of military and commercial technologies. While network technology is becoming ubiquitous in the commercial world, the demands of operating in regions without an existing mature infrastructure present unique challenges to the military. The DDR&E network program builds up from commercial products and applications to develop military unique high-end capabilities.

The DDR&E network program supplements the on-going research in the Components, and focuses on solving some of the most challenging problems in cross-Service wireless communications networking with a goal to seamlessly inter-network and operate the many diverse communications links that exist and will continue to exist in theater. This program directly addresses emerging problems the DoD has seen as a result of the Global War on Terror, such as our soldiers out-running their communications in the race for Baghdad; the hundreds of operators needed in Joint and Service Network Operations Centers to operate and fight with our increasing complex networks; and the bandwidth bottlenecks in theater, which sometimes has left our ground commanders with the choice between jamming remotely triggered IEDs or communicating. This ODDR&E program is developing the joint tools needed to address these emerging needs and will transition products directly to the field and to major acquisition programs of record beginning in 2009.

Handling Large Datasets. As the Department increases our capability and capacity to generate large amounts of data from the numerous sensors in a battlespace, the issue of handling very large data sets is becoming more challenging. For instance, the Department S&T program recently developed and deployed a high resolution sensor on a UAV in a package called "Constant Hawk". This system allows capture and replay of data in a defined area. However, as the amount of data captured grows, so do the challenges of extracting the important pieces of information from the data. This is a multi-disciplinary challenge that makes use of increased throughput communication channels with software that can be used to process the data. But, in addition to the existing systems and experiments, ODDR&E is conducting a number of demonstration programs to address the challenges of handling large data sets.

Because of the complexity and scope of the issue, the ODDR&E established a "Technology Focus Team" in fall 2007 to review the current investment and programs across the entire Department. This review included members from the Services, DARPA, and the Intelligence Community. This team had a number of recommendations, the most pressing of which is to accelerate decision making tools—through the use of such tools, machines can assist the human in handling the large volume of data.

The Large Data Joint Capability Technology Demonstration (JCTD) is demonstrating the military utility of a highly scalable (up to exabytes), globally distributed, secure data framework to support the rapid movement of massive amounts of data. The Large Data JCTD integrates technologies and operational concepts to significantly improve warfighter situational awareness by enabling rapid access, integration and visualization of huge amounts of data as if it were on the desktop. The Large Data JCTD responds to an urgent need created by the exponential growth of sensor data from sensors now overwhelming the warfighters' ability to derive actionable information. This demonstration focuses on enabling warfighter access to globally-distributed large data via an advanced global enterprise storage network (petabytes over wide area networks) implemented with advanced search and visualization applications capitalizing on the new wideband infrastructure. The first limited military utility assessment for

Large Data was successfully conducted in November 2007, with an operational focus designed to accelerate analysts' access to very large, advanced geospatial intelligence (AGI) data to enhance analysis and indications and warning. Analysts were able to do in minutes what they normally do in hours; including specific technology applications to: download/move files, access different remote files; transfer theater ISR files and mirrored data to CONUS and Korea locations; and demonstrate the transfer of a total of ~2.2 terabytes of data simultaneously. Spiral transitions of new capability have already occurred within the intelligence community. These include (but were not limited to) a 10 Gigabit/second encryption to NSA, delivering a large data solution and design (to address sharing, storage and multi-site access of large wide area optical surveillance data) to Roadrunner for JIEDDO.

Cyber Protection. Another new focus area for the DoD comes in the area of cyber protection. Over the past decade, the Department has made the concept of net-enabled operations the cornerstone of our national defense posture. The underlying assumption of the DoD's strategic vision is the availability of a robust, reliable, secure information and communications infrastructure. The level of assurance, security, and protection needed requires fundamental advances in the science and engineering that underlies our cyber infrastructure. DoD potentially faces cyber adversaries that can devote significant resources to cyber operations. This threat is well beyond the target market for commercial cyber security development.

In FY 2008, the DoD reported $179 million in cyber security and information assurance S&T, with a similar investment expected in FY 2009. Most of this funding is in DARPA which leads the DoD cyber protection research. This year, ODDR&E is leading a Department-wide effort to address and focus S&T research for cyber protection – an effort that is well connected to the President's Comprehensive National Cybersecurity Initiative. Across the DoD, we are focusing our new research in three capability trends:

- Protect Data and Networks
- Secure Information Exchange
- Attack/Event Response

To significantly change the existing game of attack and defense, the DoD needs to begin research in leap-ahead technologies to fundamentally change the game. To date, protection has been applied after-the-fact. To secure cyberspace requires a fundamental redesign of both hardware and software technology, a redesign that will come largely through the S&T program. Technology advances are needed in the following areas, all of which are being addressed by the DoD.

- Adaptive and Resilient Systems
- Accountable information flow
- Secure system and software engineering
- Security Management Enterprise Health Monitoring
- Wireless Network and Mobile Device Security

Protection Capabilities. In FY 2009, the DoD increased our budget request for the long- term in the area of active and passive armor, in response to adaptive and emerging threats (large explosively formed penetrators, rocket propelled grenades & large under vehicle explosives). The budget request enhancement is being managed by the Army with funds added to the Army S&T program, but all ground forces should benefit. By 2011, the DoD should move from metals to composites in passive armor, focusing on cost reduction efforts. By 2013, in reactive armor, the DoD should have enhanced multi-threat protection with a potential for a 20 percent weight reduction over passive armor solutions. Finally, by 2017, the program should deliver advanced passive electro-magnetic armor providing enhanced protection against multiple threats, weight reduction, and adaptable to threat changes.

The Marine Corps also added $30 million in the FY 2009 budget request to conduct focused technology demonstrations of ground force protection capabilities to demonstrate the fusion of various sensors with existing technologies to provide enhanced decision systems to better protect dismounted ground troops.

In addition to the enhanced budget request for armor protection in the Army program, the DoD Foreign Comparative Technology (FCT) program has sought potential solutions from our allies. For instance, the need for a lighter weight, corrosion-resistant material for armor protection resulted in testing of AA5059 armor produced by a German company, Corus. This material was initially intended for use as an improved repair material for M2 Bradley Infantry Fighting Vehicles with battle damage or cracking of the existing armor plate. Subsequent testing under the FCT program provided the data needed to justify risk reduction and insertion of this new armor material in support of BAE System's Mine Resistant Ambush Protection (MRAP) as a spall liner. This material is on contract for procurement through 2008. Transition is being assessed for use in the Future Combat System and Joint Light Tactical Vehicle.

Metamaterials. In the FY 2009 budget request, the ODDR&E worked with the Air Force to create a new project in metamaterials. Meta-materials have certain characteristics that can reduce the visibility of objects to either optical or radar systems. The theoretical importance and existence of Metamaterials have been progressing in foreign scientific literature since the late 1960's. However, worldwide Metamaterials research has grown rapidly since 2000 when the first negative index of refraction materials were demonstrated in Germany.

China, and a few other nations, have exponentially increased research in the past few years. In 2005 published over 250 papers in the open source literature after publishing fewer than 50 papers in previous years. A similar number were published in 2006. Additionally, the Chinese papers indicate maturing to the experimental phase. The two main application areas appear to be low observability and lightweight radar. This is a potentially "disruptive technology" area that the Department has determined requires increased attention, and has subsequently led to new start DoD projects. To accelerate the U.S program in this emerging technology area, the department has responded with applied research funding starting in FY 2009 of $15 million ramping to a sustained level of $25 million/year by 2011. The objective here will be to increase understanding of this new class of materials, demonstrate experimental methods leading to potential metamaterial structures and use metamaterials for small lightweight radars.

Energy Management. In summer 2006, in response to the growing impact the rising cost of energy has on the Department of Defense, the ODDR&E formed and led an Energy Security Task Force that encompassed all functions with the Department of Defense. As a result of the first phase of that Task Force, the Department started a number of S&T (and other type) of projects to enhance energy efficiency of platforms and installations, as well as address fuel availability. The Deputy Secretary has maintained improving energy efficiency as one of his top 25 goals. Among the S&T projects started were the following:

- The Highly Efficient Embedded Turbine Engine (HEETE), being conducted by the Air Force, is intended to develop core engine technology that could reduce fuel consumption in turbine engines by 25 percent. The Air Force is developing a high-pressure ratio, high temperature core technology. Funding in FY 2008 and 2009 is focused on the highest technical risk element – the high pressure compressor component development. This technology will support all ongoing turbine engine programs.The Small Heavy Fueled Engine demonstration also led by the Air Force, is a follow on demonstration of DARPA developed technology to use heavy fuel (standard diesel) to operate a small engine. With modern compression technology, we anticipate the potential to increase fuel efficiency and power density by 20 percent for unmanned aerial vehicles (UAVs) and generators and enable them to operate on fuels such as JP-8, to reduce the number of battlefield fuels.

- The Army is leading the "Fuel Efficiency Ground Vehicle Demonstrator", or FED, which is designed to test various potentially high-payoff fuel efficient technologies and advanced lightweight materials in innovative designs for medium tactical vehicles. We estimate these technologies could have a potential fuel savings of 30-40 percent, without sacrificing performance or capability, and a request for proposals will be released shortly. Over 40 bidders have responded to the initial request for information call.

- The Army's Rapid Equipping Force tested a transportable hybrid electric power stations (THEPS), using a combination of wind and solar energy with batteries and a generator. Field testing at the National Training Center (NTC) at Fort Irwin, California showed a need for modifications and additional hardening before being sent to forward deployed forces. The modified generators demonstrated over 90 percent savings in fuel use at low- to mid-level loads and 30 percent at high loads. A procurement decision is expected this month to expand the program.

- THEPS' concept of improving power generation and storage led to the Army's Hybrid Intelligent Power Sources (HI-POWER) program. HI-POWER is taking a holistic approach to generator power generation, management and storage through intelligent power distribution. For instance, if more power is being generated than is required, the smart system will automatically shut down some generators, thereby saving fuel. Models have predicted a 40 percent reduction in fuel consumption. A request for proposals was issued in December 2007, and multiple awards are anticipated in March 2008.

- The Navy has the lead for developing and demonstrating a family of compact and mobile high temperature fuel cell systems to power critical equipment, including GPS, radio and communications equipment, computers, intelligence, surveillance and reconnaissance gear, laser designators, and aviation ground and flight applications. These systems provide silent, portable power and eliminate dependence on large generator or grid power for battery charging. Fuel cells are highly efficient (about 55 percent) and will run on jet fuel, like JP-5 and JP-8. Fuel cells also provide a better power source in terms of weight and available energy to the soldier and auxiliary power applications for vehicles for missions over 24 hours.

DEPARTMENT OF DEFENSE BASIC RESEARCH ENHANCEMENT

Underpinning and central to the Department's FY 2009 budget request, and the push to address emerging technology areas is an increase to the Basic Research accounts of the Components. In FY 2009, the Secretary of Defense is seeking the

Congress to approve a $1.7 billion investment in Basic Research in the President's Budget Request. The request represents a 2% real increase above the $1.6 billion that the Congress appropriated for FY 2008 and a 16% increase in real terms over the Department's FY 2008 budget request for Basic Research.

The Secretary of Defense personally directed the FY 2009 budget request increase. The decision to increase the budget request for Basic Research is an important strategic decision, not taken lightly. DoD has many short-term needs against which to invest its resources. The fact that the Secretary explicitly decided, in a difficult budgetary environment, to give priority to an increased Basic Research investment indicates how critically the Department views the need to address the longer-term national defense posture. The table below shows the total funding for Basic Research in the FY 2008 President's Budget Request, the FY 2008 Appropriations, and the FY 2009 President's Budget Request, including the actual and percentage increases above zero percent real growth. All of those funds will be invested in peer-reviewed, merit-based research projects.

$M	FY08 PBR	FY08 Appropriation	FY09 PBR	Change from PBR08	Real Change from PBR08
Army	306	381	379	24.1%	21.4%
Navy	467	506	528	13.1%	10.6%
Air Force	375	408	452	20.6%	17.9%
Defense-Wide	280	338	339	21.0%	18.4%
Total Basic Research	1,428	1,634	1,699	18.9%	16.4%

The Department's investment in Basic Research has been roughly constant in real terms for more than a quarter century. The President's Budget Request reflects the position that increased investment is needed to generate new knowledge to address the greater number of diverse, rapidly evolving threats, as outlined in the QDR.

The increased budget request in Basic Research funding will be concentrated in academic disciplines that contribute to the following emerging science areas:

- Information Assurance
- Network Sciences
- Counter WMD
- Science of Autonomy
- Information Fusion & Decision Science
- Biosensors and Bio-inspired Systems

- Quantum Information Sciences
- Energy and Power Management
- Counter Directed Energy Weapons
- Immersive Science for Training & Mission Rehearsal
- Human Sciences

The funds in the President's Budget Request are allocated to the Services, Defense Advanced Research Projects Agency, and Defense Threat Reduction Agency. These funds will primarily be used to support faculty in universities for periods of up to five years each and will provide sufficient funds to permit the operation of a focused research team, to include graduate students, in an area of interest to DoD. In any case, the proposed funding increases will be allocated to peer-reviewed research to enhance the discovery of new scientific breakthroughs that should lead to a continued flow of superior military capabilities well into the future.

PROGRESS IN OTHER OFFICE OF THE SECRETARY OF DEFENSE S&T PROGRAMS

While the ODDR&E focus areas have a certain emphasis, it is important to recognize the on-going successes of the existing programs within the DDR&E portfolio. We will highlight some selected recent successes below.

Over the past year, we have had two of the longer lasting programs within the ODDR&E portfolio, the Strategic Environmental Research and Development program and the High Performance Computer Modernization Office conduct a detailed return on investment analysis. Both programs are able to show a strong return on investment.

For example, the Strategic Environmental Research and Development Program (SERDP) has invested in technologies to allow the Department to operate and train in an environmentally responsible manner. Over the past decade, the long-term return on investment for this program has exceeded 8:1. The program continues to produce, since in the past year, they have sponsored development of the Berkeley Unexploded Ordnance Discriminator (BUD). BUD is an electromagnetic system that can determine the location, size, and shape of subsurface metallic objects from a single measurement in just a few seconds, allowing for real-time discrimination of hazardous unexploded ordnance from scrap metal. Through its increased speed and accuracy, BUD has the potential to greatly reduce the time and cost of remediating munitions-impacted sites, and may also play a role in detection of buried improvised explosive devices. In recognition of its breakthrough capabilities, BUD was winner of a prestigious

2007 R&D 100 award. BUD is currently undergoing testing at multiple sites under Environmental Security Technology Certification Program (ESTCP). Its performance to date has surpassed all expectations and should significantly decrease costs of cleanup and improve the quality as well. This data will establish its performance capability and be used to convince regulators. In addition, ESTCP has a related demonstration project with a commercial sensor company who is testing variations of the BUD design for commercialization.

The High Performance Computing Modernization Program (HPCMP) has produced a large ROI, nearing 10:1 in supporting diverse areas such as acquisition modeling and weather and oceanographic forecasting. A recent S&T advance by the Department's HPCMP entails development and improvement of the Navy's global Numerical Weather Prediction (NWP) model, which is one of the world's best predictors of tropical cyclone tracks. Cyclones and hurricanes obviously have a major adverse impact on military and civilian activities. The practical impact of NWP is that the projected coastal landfall width of approaching tropical storms has been reduced from 460 miles down to 120 miles over the past several decades. This reduction has a huge positive impact in limiting unnecessary evacuations of civilian population and military assets.

To address the Department's ever-increasing dependence on complex software in military platforms and systems, DoD supports S&T investments at the Software Engineering Institute (SEI), a Federally Funded Research and Development Center (FFRDC), to advance the state-of-the-art in software technology, and to transition those advances into DoD programs. For 20 years, DoD's software S&T efforts through SEI have yielded a steady stream of technologies, such as Capability Maturity Model (CMM) and Capability Maturity Model Integration (CMMI), that represent the international gold standard for software development practices. Recent S&T advances in CMMI for Acquisition (CMMI-A), software product lines, and Architecture Tradeoff Analysis Method (ATAM) are already making a significant positive impact in reduced schedule and cost in numerous DoD acquisition programs.

The ODDR&E program also invests in another FFRDC, MIT Lincoln Lab. Lincoln Lab specializes in developing communications and information technology, advanced electronics, sensors, and integrated systems for air and missile defense. Lincoln's long-term interaction with the Missile Defense Agency resulted in the development and testing of technologies that were involved in the recent successful shoot down of the United States satellite by the Missile Defense Agency. Additionally, in the past year, the Lincoln Lab has developed and deployed an integrated prototype system that allows detection of chemical and biological agents rapidly and at low concentrations. This is a specialty system, not developed for commercialization, but it does demonstrate the potential of managing sensors and information systems in an integrated fashion.

The Joint Capability Technology Demonstration (JCTD) Program has had many remarkable successes in its first couple years replacing the ACTD Program. The JCTD Program currently has over 40 different ACTDs and JCTDs deploying prototypes to aid in the Global War On Terror as well as Operations IRAQI and ENDURING FREEDOM and has a transition rate of approximately 80% to enduring capabilities. The Mapping the Human Terrain (MAP-HT) JCTD in its first year deployed over 20 Human Terrain Teams (HTTS) to OIF & OEF. These teams have deployed an integrated, open source, human terrain data collection and visualization toolkit to support Brigade Combat teams in understanding human terrain. Prior to deployment of the MAP-HT toolkit, combat teams had severely limited Joint, Service, or Interagency integrated capability (organization, methods, tools) to effectively collect/consolidate, visualize, and understand open source socio-cultural ("green data") information to assist Commanders understand the "human terrain" in which they operate. The MAP-HT toolkit is increasing team situational awareness and enhancing interoperability with Iraqi troops and civilian leadership while improving security.

An Advanced Concept Technology Demonstration called the "Joint Precision Airdrop System" has enabled high flying aircraft to accurately parachute cargo into pre-planned drop zones. Previously, parachute resupply was problematic. Planes making the drop at low altitudes risked ground fire. At higher altitudes, winds often caused parachute loads to drift great distances away from drop zones. The JPADS ACTD developed streamlined airdrop request and control procedures resulting in facilitated delivery and reduced vulnerability and exposure to frontline troops in OEF. Since July 2006, this capability has enabled over 500 combat airdrops to more than 25 remote bases in theater, totaling over six million pounds of supplies. In October 2007, the largest single drop in one day was made to one forward base, providing over 85,000 pounds of supplies, and enough support for the winter. In several cases, these drops gave U.S. warfighters a tactical edge, providing them with ammunition and fuel to execute the fight and saving lives. Additionally, it's estimated these drops eliminated the need for over 270 ground convoys - about 2,700 vehicles and 6,200 personnel - or more than 1,000 helicopter resupply missions."

The Quick Reaction Special Projects program has three separate projects to accelerate moving technology into the hands of the warfighter. The three elements are the Rapid Reaction Fund, which primarily supports research and technology development for insurgency operations; the Quick Reaction Fund, which demonstrates technology capabilities for conventional and disruptive applications within a 12 month time frame; and the technology transition program, which seeks to move capabilities from any source into a program of record. Each of these projects has delivered successful projects. A few examples are:

Advanced Prototype Development Effort, Test & Evaluation XPAK (Explosives Particulate Analysis Kit), a system developed under the RRF to detect trace explosives and provide the warfighter with a rugged, portable system that quickly identifies traces of any of the three major classes explosives from personnel and surfaces. XPAK has shown excellent performance in a compact, robust, and low cost package. These units are currently deployed with DoD weapons intelligence teams in theater.

Human Terrain Information System project is another RRF project that provides unit commanders, their staffs and combat forces with the knowledge, training and tools needed to rapidly understand and exploit foreign cultures so that this understanding can be applied to enhance situational awareness. Since this project started interest has been high and the capability has been the foundation for, and transitioned to deployed Human Terrain Teams. These teams include anthropologists and have gathered significant media interest.

The QRF funded the development, test, and deployment of an inflatable ground SATCOM terminal, called "GATOR"; the S&T came in the application of new lightweight materials and design that allowed the antenna to be deflated and carried in a suitcase, but still allow for high-bandwidth throughput. This design replaced a heavy hard rigid antenna with something that is one-man portable. The system was tested with great success in humanitarian relief efforts by USSOCOM and during the 2007 deployment of USNS Comfort to Latin America, and is currently being procured under a contract through USOCOM. The system moved from design to test to field in under a year.

The QRF also funded a methanol fuel cell demonstration to develop and demonstrate a ruggedized fuel cell for use by dismounted industry. The company that demonstrated this fuel cell, called "Protonex", delivered a field battery charger in under 12-months, and did this in conjunction with the Army. The battery recharger is a 250 watts methanol fueled power source that over the course of a 72 hour mission can save 90% on cost and 30% on weight over using non-rechargeable batteries. It also has the potential to be used as a silent auxiliary power unit for use in mid-range power applications or by dismounted units.

The Command Post of the Future and Army Battle Command System (ABCS) Server Software Integration is a technology transition effort that provides a common commander's executive collaboration mechanism and integrates it with existing ABCS systems, significantly reducing units' logistical footprint. The initial transition to PM Battle Command to be followed by transition to Joint Common Tactical Workstation.

The Defense Acquisition Challenge (DAC) and Foreign Comparative Testing (FCT) Programs focus on near-term transition to operations and warfighter needs, testing innovative, yet mature technology and equipment for insertion into acquisition programs. For DAC, since 2003, 28 projects met testing requirements, 23 resulted in procurements, 16 which have been fielded in direct support of the GWOT. Since program inception in 1980, FCT has invested over $1 billion for the testing of coalition equipment or technology, resulting in over $8 billion of capability fielded in support of warfighting operations. Significant for DoD and taxpayers is the estimated return-on-investment of 9:1 for DAC and 7:1 for FCT

A couple of examples make the value of DAC and FCT more concrete. One of the most touted successes of the S&T program in recent years has been the "Angel Fire" capability. DAC funded the transition and suitability work for Angel Fire program. Started by the Air Force Research Laboratory and the Air Force Institute of Technology, Angel Fire brings near-real-time, wide-area, persistent surveillance to a Ramadi-sized city using an airborne platform and a Google-Earth interface. It boasts the resolution to track both people and vehicles. With the cooperation of 11 DoD organizations and a full-court press by the Marine Corp, Angel Fire deployed to the theater last year and supports currently supports daily operations. The Marine Corp has four systems now and has funded another four for delivery in FY 2008. DAC is currently sponsoring a follow-on project to add night and spot zoom capability to Angel Fire.

The FCT program has also delivered. The Marine Corp has been aggressively upgrading their M1A1 tanks based on their ongoing experience in Iraq. The German optics maker Zeiss completed an Eyesafe Laser Rangefinder for the Marines, which not only met the eye safe requirements but also increased the effective range by 2,000 meters. This has been deployed in large numbers, with 472 units purchased to date for $13.5 million and installed as a drop-in replacement for the older range finder.

The Biocular Image Control Unit made by Brimar, Ltd, in the United Kingdom supports the USMC M1A1 Firepower Enhancement Program. This unit enhances a tank crew's situational awareness by enabling the 2nd generation Forward Look Infrared imagery to be displayed in both the Gunner's primary sight monocular display and also the biocular display. These units started deploying to Marine Corp M1A1s soon after testing completed.

The Defense Technology Transfer program provides a departmental capability to transfer its technologies to U.S. companies who productize them for both military and commercial applications. The program funds efforts to facilitate Defense lab/industry collaborative R&D with companies that are often not traditional Defense R&D performers. It facilitates licensing of DoD patents. And, a DoD-wide Intellectual Property Management Information System (IPMIS) was developed and initial deployment is underway to assist DoD with leveraging DoD technology investments. As an example, TechLink facilitated a patent license agreement of a Navy developed perimeter security and surveillance system to a commercial partner for integration into their geographic information system product to pinpoint location and interpretation of remotely located acoustic events such as human or animal movement or movement of airborne or ground based vehicles. The technology offers great promise for activities such as remote border security or protection of critical infrastructure.

EDUCATING THE WORKFORCE

The final aspect to the continued reshaping of the DoD S&T program involves people. The DoD, like much of the government, currently has a science and engineering workforce that is aging. When adding in the emergence of new capability areas and the shift in underpinning science, the demands on educating and attracting the future workforce is difficult. Last year the National Academy of Sciences published a report entitled, "Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future." When the report was commissioned by Members of Congress, they asked the National Academy what actions federal policymakers could take to enhance America's science and technology enterprise in light of the global competition in the 21st century. The report presented four recommendations:

(1) Increase America's talent pool by improving K-12 math and science education,
(2) Sustain and strengthen the nation's commitment to long-term basic research,
(3) Develop, recruit and retain top students, scientists, and engineers from both the U.S. and abroad and,
(4) Ensure that the U.S. is the premier place in the world for innovation.

The DoD S&T community is deeply involved in, if not leading, each of these four areas. Under the National Defense Education Program, the Department has taken steps to address each area. The DoD is working through a pre-engineering partnership project to enhance science and math programs in K-12. This project has spanned schools in more than 13 states (growing to 20 states by 2010) and reached out to over 31,000 students and their teachers. Along with our science and engineering enrichment programs for middle and high school students, we have partnered with college and graduate students to further their education in science, technology and engineering.

In S&E education, the DoD has two projects that are specifically targeting university students and researchers for the DoD. Our programs like SMART, (Science, Mathematics and Research for Transformation) scholarships are effective in engaging intelligent, motivated young people and helping them excel in these critical disciplines. Currently 29 graduates have entered the DoD workforce from SMART scholarships, 134 students are now in school supported by SMART, and more than 100 new SMART scholars will receive awards in FY 2008. Responding directly to the Academy's recommendation, this year DoD will award up to ten National Security Science and Engineering Faculty (NSSEFF) Fellowships that will attract the best physical scientists and engineers in academia to work on DoD's long-term basic research challenges.

SUMMARY

In closing, Mr. Chairman, I would once again like to thank the committee for the support of the Department of Defense Science and Technology program, and seek your continued support of the programs laid out in the FY 2009 President's Budget Request. The on-going emphasis of this Administration to the science and technology program is providing new capabilities for the men and women of our armed forces and revitalization of the Nation's S&E workforce, but the job is not done. Our armed forces deserve the best technologies and capabilities we can provide to them as we work together to expand the S&T program into new and exciting areas. With your help, the Department has been able to expand the Basic Research program signaling a strong commitment to deliver unimaginable capability to our armed forces well into this century. We seek your continued support for both the basic research expansion and the overall S&T program. With the continued support of Congress, the Department's S&T program will continue to deliver those superior capabilities our men and women in uniform deserve.

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
RESPONDING TO THE CHANGES AND
CHALLENGES IN THE TWENTY-FIRST CENTURY
IRREGULAR WARFARE THREAT ENVIRONMENT

SECOND SESSION, 110TH CONGRESS

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INTRODUCTION

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to describe the fiscal year (FY) 2009 Army Science and Technology (S&T) Program and the significant role of S&T in supporting the warfighter today and in achieving the Army's Transformation.

We want to thank the Members of this Subcommittee for your sustained support of our Soldiers who are at war and for funding the investments that will provide future Soldiers with the dominant capabilities they need to defend America's interests and those of our allies throughout the world. Your continued advice and support are vital to exploiting the potential of technology for victories on the battlefields of today and tomorrow.

S&T INVESTMENT STRATEGY

The Army's S&T investment strategy is shaped to pursue technologies that create unmatched and unprecedented capabilities for the future land combat forces while leveraging early instantiations of these capabilities for the warfighter of today.

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 these needs. I would like to highlight several of the areas that are applicable to the irregular warfare environment as illustrations of the Army S&T community's contributions to enhancing the current warfighting capabilities. The Army S&T community has developed and assisted in the fielding of passive armor solutions that provide tactical wheeled vehicles with ballistic protection that rivals combat vehicle protection. We have created improved Soldier body armor that protects extremities, shelters that withstand mortar attacks, and detection and neutralization systems for use against improvised explosive devices (IEDs). We have made advances in command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) providing the warfighter in theater with improvements in advanced imagery and signal sensors and network-centric battle management tools. We have enabled our Soldiers to attain decisive results with reduced collateral effects by providing precision capability for the guided multiple launch rocket system and the Excalibur 155mm artillery munition. But we recognize that the warfight is not just about the technologies that provide overmatch capability but about the men and women who conduct this warfare. In keeping with our commitment to the Soldier health and well-being, we have developed medical technologies such as Battlemind Training, a tool used to prepare the warfighter for the rigors of combat and to help them reintegrate into non-combat environments on their return home.

Our major investments in the core S&T program are best understood in terms of Future Force technology areas. The following paragraphs describe the types of investments within five key Future Force technology areas:

1) Force Protection technologies. We are developing active and passive protection technologies to increase the survivability of Soldiers, rotorcraft, and ground vehicles. This includes the ability to track, engage, and defeat rockets, artillery rounds, and mortars; detect and neutralize IEDs/mines; and protect against traditional threats to tactical and combat vehicles. Major investments in Force Protection include the development of new materials, models, and armor formulations for increased ballistic protection at reduced weights for Soldier, tactical, and combat vehicles; 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. This budget requests an increase in funding for new initiatives in active armors, such as electromagnetic armor and improved energetic materials for reactive armor, both designed to defeat emerging and future threats at reduced weight.

2) 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 multi-functional radars for extended range detection and identification in foliage, in urban areas, through walls, as well as individual targeting and tracking. 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.

3) Lethality technologies. Investments leverage development of next generation explosives and reactive materials to enable controlled lethality warheads that enable scaleable effects in a single munition – yields that can be selected based on the intended target, thereby minimizing unintended collateral effects; low-cost seeker and guidance technologies that enable greater precision at an affordable cost; technologies that increase munition safety without degrading performance (insensitive

munitions); and electromagnetic gun technology to achieve unprecedented lethality with a lower logistics burden.

4) 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 protection, treatment, and life-saving interventions for Soldiers. This program has three components: combat casualty care (inclusive of blast trauma from explosive devices); infectious disease (diagnosis, treatment, and preventatives); and military operational medicine (to enable effective performance under environmentally extreme conditions worldwide). The Army is leading a joint medical program focusing on the prevention, mitigation, and treatment of medical blast casualties sustained from IEDs and other sources of blast-related wounds. In addition, we have begun an investment in tissue regeneration research with the ultimate goal of developing technologies that will lessen the impact of severe and debilitating wounds by regenerating skin, nerves, muscle, and eventually bone.

5) Soldier System technologies. Our investments in Soldier technologies seek to provide individual Soldiers with "platform-level" capabilities. These include greater protection, networked communications for shared local and extended situational awareness, as well as connectivity that allows

the Soldier to exploit joint lethal fires. 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. Key Soldier technology investments include: advanced body armor; lightweight novel power sources including fuel cells; and sensors and network links that put the Soldier on the "net" In the challenging "urban canyons" that are and will continue to be the focus of operations, particularly in irregular warfare.

BASIC RESEARCH PROGRAM

In the 2009 budget request we have increased basic research funding by 24 percent over the 2008 request, making basic research our largest single investment area within the S&T portfolio. This increase in Army basic research will leverage the substantial investments in research throughout our economy to produce unprecedented increases in capability for the Army. The basic research investments create the potential to maintain and increase the nation's superior land warfighting capabilities and reduce our risk for an uncertain future. The fundamental underpinnings of technology that we are pursuing with this investment will make it possible to conduct ever more complex military operations, with greater speed and precision, and to devastate any adversary on any battlefield. Army basic research continues to explore breakthrough opportunities in network science, neuroscience, biotechnology, immersive technology, quantum information science, nanotechnology, and autonomous systems. The Army has also increased funding to establish research initiatives in human, social, cultural, and behavioral modeling; modeling and analysis of complex, multi-scale networks; and neuroergonomics—leveraging our emerging understanding of how the brain works to create more effective system interfaces and training tools and techniques.

SCIENCE AND ENGINEERING WORKFORCE

To maintain technological superiority now and in the future, the Army needs to hire top quality scientists and engineers into the Army Laboratories and Research, Development, and Engineering Centers. This is especially daunting given that 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 and direct hire authority to enhance recruiting and reshaping of the workforce. These initiatives are unique to each laboratory allowing the maximum management flexibility for the laboratory directors as well as allowing them to be competitive with the private sector. Finally, we have long recognized that a scientifically and technologically literate citizenry is our nation's best hope for a diverse, talented, and productive workforce. To pursue this goal, we leverage the numerous resources across our programs and the Department of Defense (DoD) to engage America's youth in science, technology, engineering, and mathematics.

TECHNOLOGY TRANSITION

Successful transition of Army S&T products to programs such as Future Combat Systems (FCS) is central to enabling the Army's transformation. With the Army's focus on support to current operations, the Army S&T strategy has expanded to include the pursuit of enhanced capabilities for the Current Force while continuing to develop and mature transformational capabilities for the Future Force. Within the Army S&T community, we conduct program reviews to assure ourselves that technology development efforts are on track to deliver products to the program manager (PM) that perform as required, have the appropriate maturity level, are on schedule, and are still supported by the Army. DoD policy requires that all technology in a program preparing for a Milestone (MS) B decision must be demonstrated at a technology readiness level of six or better, lessoning the occurrence of "immature" technologies that account for cost and schedule overruns in major acquisition programs. When a program is preparing for its MS B decision, the Deputy Assistant Secretary of the Army for Research and Technology conducts decision reviews that assess and certify that the technologies to be used in the program are sufficiently mature. This teamwork between the S&T and acquisition communities improves overall long-term success of Army technology transition processes and programs.

SCIENCE & TECHNOLOGY SUCCESS STORIES

I would like to describe a few recent examples of successful S&T efforts that have transitioned to programs of record:

- Mounted Combat System (MCS) and Abrams Armament Systems Technologies. This effort developed technologies to enhance capabilities of the Abrams Main Battle Tank and the FCS Mounted Combat System (MCS) ammunition suite. It demonstrated an integrated dual mode (autonomous and designated) Mid-Range Munition (MRM) for the 120mm gun. The MRM provides a precision, beyond line of sight capability of up to 12km. The MRM transitioned to Program Manager Maneuver Ammunition Systems (PM MAS) in FY 2007 for an FY 2008 Systems Development and Demonstration (SDD) start. The effort also demonstrated the Line of Sight Multi-Purpose Munition which provides overwhelming lethality from a single munition against multiple target types. This effort also transitioned to PM MAS for an anticipated SDD in FY 2010.

- Hybrid Electric Drive Components for Future Combat Systems. We developed, characterized, and validated the performance of advanced hybrid electric power system component technologies for improved mobility, survivability, lethality, and fuel efficiency for FCS. This energy and power technology for FCS ground vehicles will enable silent watch, silent mobility, enhanced dash speed, and reduce signatures (acoustic, thermal, visual, electromagnetic interference).

- Future Force Warrior (FFW) Technology. The FFW technology effort demonstrated an integrated, modular combat ensemble with reduced fighting load, improved individual mobility, fight-ability and human performance. FFW developed a system-of-systems capability, successfully demonstrating technologies for a fully integrated dismounted combat system, including weapon, head-to-toe protection, netted communications, and Soldier-worn power sources enabling enhanced human performance. The technologies enable revolutionary warfighting capabilities including network interconnectivity with existing and emerging networks at the Soldier and small combat unit level while reducing fighting load and power requirements, and improving Soldier protection, lethality, and situational awareness. This program transitioned the FFW concept and data to PEO Soldier.

- Novel Energetic Materials. The novel energetic materials effort focused on creating a new family of revolutionary low cost insensitive explosive formulations with better performance, enhanced weapon lethality, and increased safety. The effort demonstrated new high-nitrogen gun propellants for 120mm tank cannon and 105mm light artillery that provided a 20 percent increase in muzzle energy and a 40 percent reduction in gun tube wear.

CONCLUSION

The S&T portfolio contributes to addressing the Army's critical challenges and restoring balance in our forces through the four imperatives: Transform, Sustain, Prepare, and Reset. It has and will continue to enable the success of the Future Combat Systems program as well as exploiting technology opportunities through the FCS spin outs (Transform). Emerging medical technologies enable improved care for our wounded Soldiers and will enhance their future quality of life (Sustain). Advanced training technologies will accelerate the preparation of our Soldiers and leaders to operate in complex 21st century security environments (Prepare). Technology insertion opportunities and advanced training can contribute to resetting the force to prepare for future deployments and other contingencies (Reset).

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.

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 war on terrorism to ensure that the Army remains a victorious, relevant, and ready 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
REAR ADMIRAL WILLIAM LANDAY, UNITED STATES NAVY
CHIEF OF NAVAL RESEARCH

BEFORE THE
TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES SUBCOMMITTEE
OF THE
HOUSE ARMED SERVICES COMMITTEE
ON
DEFENSE SCIENCE & TECHNOLOGY POLICY AND
THE FISCAL YEAR 2009 BUDGET REQUEST

MARCH 13, 2008

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Introduction

It is an honor to appear before you to update you on Science and Technology (S&T) efforts within the Department of the Navy and to discuss how the President's Budget Request for FY 2009 supports the Navy and Marine Corps team.

The Naval S&T challenge is to enable revolutionary operational concepts that support the Navy and Marine Corps vision of the Secretary of the Navy, Chief of Naval Operations and Commandant of the Marine Corps. They envision a force that is expeditionary, distributed, persistent, forward deployed and capable of prevailing in any scenario manifested by today and tomorrow's threat environments. Leveraging innovative concepts, advanced technologies, and new business practices to increase fighting effectiveness, the Office of Naval Research (ONR) S&T portfolio plays an increasingly critical role in the Navy and Marine Corps' strategic vision.

In order for our S&T enterprise to address critical problems facing today's fleet and force, as well as the Navy/Marine Corps of tomorrow – we must do three things: First, focus on areas that provide the biggest payoff for the Navy/Marine Corps of the future. Second, be innovative in our thinking, science, and business processes. Third, improve our ability to transition S&T to acquisition programs and into the Fleet. The President's Fiscal Year 2009 Budget requests $1.84 billion in the Navy S&T portfolio to accomplish these goals. This reflects a 6% increase over the requested FY 2008 level.

S&T Strategic Plan

Early in 2007, an updated Naval Science and Technology Strategic Plan was approved by Navy and Marine Corps leadership. It ensures alignment of Naval S&T with current Naval missions and future capability needs. It also ensures that S&T has a long-term focus, responds to near-term requirements, and makes our vision clear to decision makers, S&T partners, customers and performers. The Strategic Plan identifies 13 key areas where S&T investment will have high payoff in supporting the Navy and Marine Corp requirements. Those areas are:

NAVAL S&T STRATEGY FOCUS AREAS

- Power & Energy
- Operational Environments
- Maritime Domain Awareness
- Asymmetric and Irregular Warfare (Combating Terrorism)
- Information, Analysis and Communication
- Power Projection
- Assured Access and Hold at Risk
- Distributed Operations
- Naval Warrior Performance and Protection
- Survivability and Self-Defense
- Platform Mobility
- Fleet/Force Sustainment
- Affordability, Maintainability, Reliability

Examples of work we are doing in these areas include:

In the Information, Analysis and Communication Focus Area we are working to enhance decision making tools, reduce information overload, and prevent disruption-causing degradation to enable a commander's decision making at both tactical and strategic levels. We want to promote rapid, accurate, decision making by providing decision aids, enhanced communication networks, and security in an increasingly active cyber war environment. We have identified key research topics that will move us toward achieving these goals.

In the Naval Warrior Performance and Protection Focus Area, our goal is to enhance warfighter performance in all environments through training technologies, human systems integration, and casualty management. We want to shorten training time, maximize training impact, enhance understanding of human cognition and stress in combat environments, and equip forces with the resilience to successfully adapt to a full range of military experiences and threats. We are concerned with issues ranging from providing lighter armor and equipment, to human factors associated with organizational design and resource management.

In the Affordability, Maintainability and Reliability Focus Area, we want to reduce acquisition and life cycle costs for platforms and systems through new design tools, reduced maintenance, intelligent diagnostics, and automation. We want to make platforms affordable, durable, reliable, predictable, energy efficient, wear and corrosion resistant, at the same time we reduce manpower requirements. We have identified key research topics to move us toward achieving these goals.

Executing the Strategy

We execute our Basic Research (6.1) thru Advanced Technology Development (6.3) funds by breaking the S&T continuum down into three key areas – Discovery and Invention (D&I), Innovative Naval Prototypes (INP), and Future Naval Capabilities (FNC).

Discovery & Invention

Discovery and Invention (D&I) is basic research and early applied research (6.2) focusing on areas where we have unique naval needs or support capabilities essential to the naval mission. We believe investment in this area is necessary to ensure we maintain technical advantages for our Naval forces. The D&I vision is to develop Naval-relevant fundamental knowledge, provide the basis for future Navy/Marine Corps systems, and maintain the health of the Defense Scientist and Engineer workforce.

Approximately 41% of our S&T investment is in our D&I program. This represents a $75M increase over our FY 2008 Budget request. This increase supports our historically strong commitment to the foundational work done in D&I and reflects the desire of the Congress, President and Secretary that we maintain a robust and vibrant Basic Research investment. We allocate that money across core research areas through a rigorous process to weigh relevance, impact on the Navy/Marine Corps mission, and potential for innovative performance in order to select the best mix of research areas and projects. This builds the foundation of our S&T portfolio, developing a broad base of scientific knowledge and innovation from which our INP, FNC, and quick reaction efforts are generated.

One new initiative in this area is a Basic Research Challenge Program designed to stimulate new investments focused on opportunities that exist in the seams between technical fields of science. These represent new areas of research for ONR with an ability to attract new researchers in such areas as: 1) Quantum Information Sciences and the Future of Secure Computation, 2) Autonomous Devices for Advanced Personnel Treatment, 3) Brain Imaging of Active Cognition in Mobile Environments, and 4) Compressed Sensing for Networked Information Processing.

In 2007 we conducted a rigorous review of approximately half the D&I portfolio. An external panel (including experts from university, industry, and other DoD organizations) examined research areas to assess performance with respect to Naval impact, S&T quality, and programmatic risk. The panel also reviewed overall direction of the portfolio, evaluated whether there were promising research areas we had not invested in, and additional opportunities for collaboration. The panel found that overall performance of the D&I portfolio was very strong; while encouraging expanded collaboration in multidisciplinary areas such as sensors, autonomy, and networking. We will conduct another peer-review of the other half of the D&I portfolio this June.

Highlights of contributions resulting from D&I investments include:

Human Behavior Modeling, with the goal of developing instructional systems and models of human cognition and performance, supports the design of advanced, simulation-based, Naval training systems. Accurate modeling of individual behavior poses only moderate technical challenge, but computational modeling of groups, teams, crowds, and organizations is highly challenging and involves modeling communication, co-ordination, group cohesion, and cultural influences. This program seeks to develop realistically behaving synthetic crewmates and adversaries to provide challenging training for Navy and Marine Corps warfighters with effectiveness and affordability far exceeding what is currently available. Elements of this program, such as modeling of synthetic insurgent forces for Marine Corps urban warfare training, transitioned to the U. S. Marine Corps (USMC) Deployable Virtual Training Environment Program in FY 2007.

An important enabling component of D&I is the Defense University Research Instrumentation Program (DURIP), designed to support the university research infrastructure essential to high quality Navy relevant research. This instrumentation program complements other Navy D&I programs by supporting the purchase of high cost research instrumentation necessary to carry out cutting-edge research. ONR awarded 68 grants to universities to purchase instrumentation to support D&I research in FY 2007, expects to award approximately 80 grants for that purpose in FY 2008, and estimates the award of 140 grants for that purpose in FY 2009.

One of the largest contributions made through D&I investments is development and sustainment of the S&T workforce. In tandem with participants in the Naval Research Enterprise (NRE), we provide outreach, education and research opportunities to a diverse population of undergraduate and graduate students, fellows, future faculty members and researchers. This is achieved through specific programs which expose students and researchers to the work done at Naval laboratories, as well as other research opportunities. We support the HBCU/MI community through targeted education and research partnerships. Through a variety of demonstration, apprentice, awards, and graduate programs, we encourage young men and women to consider and explore S&T careers in academia, the Naval labs, and industry.

Innovative Naval Prototypes

The Innovative Naval prototype (INP) program continues to show great progress in 2007-2008 and the FY 2009 investments will keep it on track. INPs are the primary portion of our Leap Ahead Innovations portion of the S&T continuum which is $197M or 11% of the budget request. They focus on those high risk, high payoff, game changing opportunities emerging from the D&I portfolio that can have a significant impact on naval capabilities if we can mature the technology sufficiently. Because these efforts are often discontinuous, disruptive technologies that may represent radical departures from established requirements and concepts of operations, they are approved and overseen by the DoN S&T Corporate Board consisting of the Assistant Secretary of the Navy (RD&A), the Assistant Commandant of the Marine Corps and the Vice Chief of Naval Operations. The goal is to prove out the concepts and mature the technology within 6-12 years to allow informed decisions on whether to transition it to an acquisition program of record and to have significantly reduced the technological risk at the time of transition.

We have seen major milestones met in all four of our current INPs. We have developed and tested a new more powerful lab gun in our Electromagnetic Rail Gun program. Our tactical satellite program has met all of its goals and will complete in FY 2010 with most of the technology and some of the people transitioning to the Operationally Responsive Space program. We completed a major trial of our Persistent Littoral Undersea Surveillance (PLUS) program and conducted a major Autonomous Underwater Vehicle (AUV) trial with over 70 vehicles from all over the world participating. Finally, we have selected three intriguing concepts for further design and model testing in our Seabasing Enabler program. Additionally, we have increased investments in our D&I programs in anticipation of starting two new programs targeted for FY 2010 – moving the Navy to fight at the speed of light by bringing high power laser technology to sea for ship defense and dominating the electromagnetic spectrum through the development of multifunction apertures for all classes of ships. A key component of this effort is to look at the ability to bring the concepts of open architecture to hardware systems as well as software.

Future Naval Capabilities (FNCs)

One of our highest priorities continues to be improving transition of deployable S&T products, more rapidly and with less risk to acquisition managers or directly to end users. We are building regular, early partnerships between scientists and acquisition managers in an effort to improve transition. It is critical that acquisition managers understand what capabilities and technologies are on the way from S&T and that they determine how they best fit in their program of record, well before they arrive. It is equally important for S&T managers to understand factors driving acquisition managers, and be sensitive to when acquisition managers are best able to handle new technologies and when the window for inclusion of new technology is closing. In the past, that relationship was often established too late for us to be as effective as we could be.

While not the only means for S&T to transition to the Fleet, our Future Naval Capability (FNC) program is the most critical component of our transition strategy. FNC investments were restructured in 2005 to better align this "requirements-driven, transition-oriented" portion of the S&T portfolio to Naval Capability Gaps identified by OPNAV and Marine Corps Combat Development Command (MCCDC) through the Naval Capabilities Development Process.

As opposed to high-risk/high-payoff INP projects, FNCs involve more near-term projects. FNCs are included in the portion of our budget focusing on Acquisition Enablers (totaling $655M or about 36% of our overall budget). The FNC process delivers maturing technologies to acquisition managers for timely incorporation into platform, weapon, sensors, and process improvements.

FNC projects are based on earlier D&I investments, where technology has matured to the point that they 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/USMC, U.S. Fleet Forces Command (USFF), Assistant Secretary of the Navy for Research, Development and Acquisition (ASN-RDA) and ONR. Enabling Capabilities (ECs) selected represent the highest Navy/Marine Corps priorities.

All 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 Fleet/Force. Every FNC product's progress and transition status is reviewed annually. Products that no longer have viable transition paths are terminated and residual funding used to solve unexpected technology development problems with existing ECs, or start new ECs, in strict compliance with established DoN priorities.

There are currently 169 FNC projects underway in various stages of their 3-5 year development. 36 are expected to complete and transition in 2008. The FY 2009 budget request continues funding for the remaining projects and initiates an additional 28. FY 2008 transitions include algorithms and computer programs for integrating real-time sensor data and non-real time data to reduce target track and identification conflicts; integrating object recognition and tracking algorithms, machine vision, multiple network video streams, geospatial data and operational context to flag atypical activity and recognize known threats;

We plan to complete and transition an additional 20 projects in FY 2009. They include a single stress tolerance metric for implementation into the Aviation Selection Test Battery, a buoy-based deep water active surveillance system to maximize Anti-Submarine Warfare engagements, and upgrades to guided and unguided weapons through the addition of fire and forget/off boresight capability.

The critical measure of success of this program is whether the project met its technology requirements and exit criteria, and whether the acquisition program manager has transition funding within the program plan to accept and integrate the FNC product into the program. As shown in the table below, we have had good success in this effort and continued to improve our transition rate from 2005 to 2007. We expect equally strong performance in 2008.

FNC Transition Summary	FY05		FY06		FY07	
	# Products	% Plan	# Products	% Plan	# Products	% Plan
Products Planned to Complete	30		27		41	
S&T Completed or near complete with Manageable Risk	28	93%	26	96%	39	95%
S&T Completed or Near Complete and Transition Funds Programmed	20	67%	25	93%	29	71%
S&T Completed or Near Complete and Transition Funds Planned	4	13%	0	0%	8	20%
S&T Completed and No Transition Funding	4	13%	1	4%	4	10%

Increases and Decreases in FNC Funding Levels

Because FNC investments are not level funded, but focus on the most pressing capability gaps identified each year, they generate movement in funding levels for the associated PEs from year to year. Since FNC investments mature and develop technology products over a 3-5 year period, the Technology Readiness Level (TRL) of the underlying products moves from 6.2 PEs to 6.3 PEs. Typically, but not always, the first year of an EC is predominantly 6.2; the final year is predominantly 6.3 – with a mix of 6.2/6.3 in-between. Furthermore, in a given year, as products are delivered and transition to Advanced Component Development and Prototypes (6.4) funding, new FNC projects are not necessarily in the same PEs as those just completed. Although these changes may appear to be PE program growth, they actually reflect realignment of funds in response to successful technology transition – coupled with reprioritization based on evolving Naval needs and requirements.

Current S&T Program Highlights

In the Naval S&T portfolio there are a wide range of projects either entering the fleet or poised to do so in a short time. I have included examples of those efforts with respect to the direct impact they will have on Sailors and Marines, both today and in the future.

Manpower, Personnel, Training and Education (MPT&E)

For FY 2008, ONR's Capable Manpower FNC is focused on developing innovative, technology-based products to support Navy/Marine Corps Human Capital programs. These include manpower, personnel, and training products that will provide new approaches to selection, classification, training, distribution, assignment, and job performance to ensure that future combatants and sea-service components are properly staffed for optimal readiness.

In the domain of manpower and personnel the Force Utilization Through Unit Readiness and Efficiency (FUTURE) program blends behavioral research and economic theory in a virtual experimental environment. It employs artificial intelligence and optimization techniques to create simulation-based decision support tools to determine resource allocation and cost-benefit assessments across units and battle groups. Web-based tools house a multifaceted simulation environment to assess the impact of alternative human resource allocation policies on individual, team, and unit efficiency, readiness, and costs. This research provides unprecedented visibility over costs, enables Navy to decentralize human resources management, and enables a deeper understanding of how policies and incentive options affect behavior.

Human Systems Integration training products are under development to enable advanced design methodologies and tools supporting rapid, spiral, human-centered design processes which will support the total life cycle of complex naval systems. Further, Capable Manpower is studying methodologies to improve commanding officer/crew situational awareness in the increasingly stressed tactical and strategic operations of the 21st Century.

We are working to improve training for Expeditionary Warfare by developing and evaluating company/battalion-level command and control (C2) performance support systems, automated performance assessment, real-time/model-based performance diagnosis and training strategies. This will support multi-tasking in team environments, provide system assistance based on dynamic monitoring of user-state and system-state, and increase skill proficiency and retention.

Infantry Immersion Trainer

The Infantry Immersion Trainer (IIT) is a revolutionary training system that prepares Marines and Sailors for deployment to today's battlefields. The facility uses virtual reality, actual physical structures, and live role players to re-create foreign urban scenes – right down to the sounds and smells – to give troops the necessary skills to win and survive in battle. The first IIT facility opened in December, 2007, at Camp Pendleton. The IIT environment places warfighters in a realistic combat scene, confronting them with a range of possible scenarios that require split-second decisions and action. The high-tech simulation provides a safe environment for learning how to prevent fatal errors before being exposed to the real threat. IIT uses sets, sound systems and special effects – including holograms and pyrotechnics – to simulate a Southwest Asian village in the midst of combat. Equipped with laser-tag-like weaponry, Marines walk through realistic dwellings, alleys and other settings, encountering civilians and enemy combatants for a more realistic training experience.

IIT software-based systems allow for rapid improvement of training delivery and the simulated scenarios can be tailored to suit mission or individual needs. Repeatable and scaleable scenarios increase skills in less time, and sights, sounds, and smells of combat are reproduced in exacting detail. A second IIT facility is scheduled to open at the Marine Expeditionary Rifle Integration Facility in Quantico in 2008. The IIT system incorporates several ONR-sponsored technologies, DARPA initiatives in game-based simulators, as well as technologies sponsored by the U.S. Army Research Development and Engineering Command's Institute for Creative Technologies at the University of Southern California.

Marines in the Urban Environment

Urban combat presents challenges above and beyond those present in rural combat or more open environments. Particularly challenging are communications, GPS reception, intelligence collection and dissemination, and observation and location of enemy forces. Building, walls, and similar structures, along with their complexity, make urban combat costly in time, effort, and forces required.

We are working to develop technologies that will give our forces distinct advantages in urban combat. In conjunction with Army and DARPA efforts, we are advancing "See-thru-walls" technology to enable Marines to locate people inside buildings and individual rooms prior to entering. This will help take the initiative from the enemy and give it to our Marines, while increasing force protection at the same time.

Finally, work continues to develop "trajectory shaping" for the 81mm mortar to allow precision fires in an urban environment. The 81mm mortar is organic to Marine Infantry Battalions and can provide immediate fire support. The complexity and structures of the urban environment greatly limit accuracy and effectiveness of these weapons. The ability to "shape" the trajectory will allow greater use, accuracy, and effectiveness of these weapons.

Improvised Explosive Devices (IEDs)

Working closely with the Joint IED Defeat Organization (JIEDDO), ONR funds research efforts aimed at attacking both IED networks and devices, as well as enhancing training for our forces. We are committed to research complementary to other DoD and U.S. efforts and to fostering collaboration with our allies.

In conjunction with work in other agencies, ONR is investing in prediction efforts involving dynamics of terrorist movements, analysis of human activity associated with placement, uncovering support networks, tracking factory locations and events, bio-forensic profiling for tracing place of origin, and dynamic analysis of suicide bombing. These projects anticipate future threats, as well as put us in a better position to respond as conditions change.

Detection efforts are geared towards enhancing the ability to achieve persistent surveillance of the battlespace – understanding, identifying, and locating activities associated with manufacture, transport, and placement of IEDs. Near-term initiatives include the Marine Corps Advanced Technology Development efforts to neutralize IEDs through improved countermeasures as well as locating and directly attacking the device.

ONR is heavily involved in maturing technologies and concepts that support the Joint Light Tactical Vehicle, advanced lightweight personnel protective equipment, and medical prevention and treatment of traumatic injuries to our Sailors and Marines. In addition, ONR has increased emphasis on countering IED threats in the Riverine environment. This environment poses unique challenges different from their land counterparts.

As the science behind these approaches matures, we continue to work closely with JIEDDO, and other organizations, for implementation in mature systems and push the enhanced capabilities forward for the warfighter. Through the outreach efforts of our program officers and the ONR Global office, we continue to expand and enhance our collaboration with international partners.

Medical Research related to IEDs and Hearing Loss Prevention

ONR continues to work closely with the medical community to understand the devastating effects from IEDs and has collaborated with many organizations to develop a tool to connect medical and event data to allow in-depth analysis. Warfighter Protection Advanced Technology Development efforts include modeling of human response to blast, ballistic, and blunt trauma effect, as well as modeling physical and cognitive effects of blast exposure and conditions arising from traumatic brain injury.

Another area of emphasis is on reducing the damage caused by personnel operating in high noise environments. We have been challenged by Navy and Marine Corps leadership to address this problem and are working closely with the medical, acquisition and S&T communities to attack this from multiple approaches to reduce the noise generated, attenuate what noise still exists, monitor and assess exposure, and warnings and procedures to ensure that exposure does not become damaging and finally treatment in the event potentially damaging exposure does occur.

Vertical Lift

In recognition of the important role, and potential enhanced capabilities, of rotorcraft in current and projected combat operations, humanitarian relief, and other important Naval missions, ONR continues to invest in vertical lift technology. The current program includes research into new concepts such as a dual ducted fan vehicle for urban operations, vehicle systems for automated resupply, and options for a future Joint Multi-Role aircraft.

Technologies of particular interest to Naval applications, such as durable composite structures and modeling of ship and air wake interactions, including air vehicle dynamic interfaces, are being developed. Technology investments to enable future high speed vertical lift aircraft are being leveraged through partnership with the Army and Defense Advance Research Projects Agency (DARPA) in the Joint Heavy Lift (JHL) program. The ship compatibility attributes of a potential future JHL are also being investigated.

ONR continues its commitment to the rotorcraft community by partnering with the Army and Federal Aviation Administration (FAA) in applied research investment via the National Rotorcraft Technology Center (NRTC). These investments not only show benefits from the synergy of collaborative planning and execution, but are cost shared by the Center for Rotorcraft Innovation, a consortium of industry and academia.

In basic research, our long-term vision for Vertical Take Off and Landing (VTOL) aircraft combines improved Naval mission effectiveness, increased affordability, maintainability, reliability, and unprecedented levels of safety and survivability for aircrews. To achieve these breakthroughs we will join with the Army in the Vertical Lift Research Center of Excellence, with participation from Navy labs, Air Force, NASA researchers, and the most highly qualified and innovative performers from academia.

Power Projection and Time Critical Strike

Revolutionary Approach To Time Critical Long Range Strike (RATTLRS) is a Navy, Air Force, NASA, and OSD interagency cooperative program, to develop a high speed non-afterburning turbine, Mach 3 flight demonstration program for a future expendable high speed strike weapon, while also enabling potentially new options for access to space. We are projecting to achieve first flight in FY 2009, with a non-afterburner high-Mach turbine engine accelerated flight demonstration.

While still being developed, RATTLRS has already generated interest, support, and transitioned some subsystems technologies into advanced applications. For example, the Air Force Research Laboratory (AFRL) and DARPA, transitioned the RATTLRS core engine to further development for the joint HiSTED (High-Speed Turbine Engine Demonstration) program and plans to ground test the engine near Mach 4 flight conditions in 2008.

Additionally, the DARPA/USAF Falcon HTV-3X Program is developing a turbine based combined cycle (turbojet/dual-mode scramjet) propulsion testbed known as Blackswift. The Falcon program plans to use RATTLRS core engine for its turbine accelerator, as well as RATTLRS airframe fuselage and control surface manufacturing techniques.

Affordable Platforms

ONR efforts such as the Navy Manufacturing Technology (ManTech) Program and our Enterprise & Platform Enablers FNC contribute to improving affordability in acquisition programs and throughout the lifecycle of systems and platforms.

The CNO's directive on affordability and cost-cutting in shipbuilding led to a major restructuring of the Navy ManTech portfolio in 2006. This reemphasis led ManTech to focus on shipbuilding solutions that cut acquisition costs. Currently, ManTech has focused shipbuilding affordability initiatives with four platforms: DDG 1000, CVN 21, Littoral Combat Ship, and VIRGINIA Class Submarines.

For example, the Virginia Class Submarine (VCS) Focused Initiative has 31 active projects with approximately 24 more slated to begin later in FY 2008-09. Projects are focused on developing and transitioning process improvements involving Design for Production, Production Planning, Schedule Compression, and Outfitting. ManTech, in concert with the contractors and Program Office, bi-annually assesses likely cost savings resulting from implementation of the developed technology. In the most recent assessment, 33 VCS projects were reviewed involving a combined ManTech investment of approximately $28.0M, with resulting savings estimated to exceed $36.3M per hull.

The FNC program has been equally active in this area with technologies transitioning in FY 2007 in such areas as engine turbine technology, advanced coating and components, improved aircraft circuit breaker designs, non-destructive testing of composite structures, and corrosion reduction. It has been estimated that these programs alone will save more than $1.8B over the lifecycle of the numerous systems and platforms where they will be applied.

Future Power Systems

ONR is investing in advanced technologies for high efficiency electrical systems and equipment to meet the increasing electric power requirements for advanced weapons, launchers and defense systems aboard ships and submarines. Our S&T focus is on technologies and system architectures to increase power and energy densities and energy efficiency, with the goal of reducing the impact of high-power electrical power systems on ships. These efforts directly support NAVSEA's Electric Ship Office's (ESO) Next Generation Integrated Power Systems Roadmap.

In coordination with the OSD focus on energy security, we initiated a Naval Future Fuels effort to investigate the impact of new fuel formulations on Naval machinery. Additionally, we are using the FY 2008 committee initiative for alternative energy to augment and expand Department programs in energy security related programs in advanced, high efficiency solid oxide and direct boron hydride fuel cells and continue to support research in methane hydrate, biomass, wave action, and other alternative sources of energy.

Electromagnetic Warfare and Cyberspace

This budget request continues a strong investment in our ability to ensure we can operate while inhibiting an adversary's ability to use the electromagnetic spectrum. Additionally we have strengthened our investment in cyber space, particularly in the areas of protection, information assurance, anti-tamper protections, information and software science. Recent CNO Strategic Studies Group work on cyberspace and maritime operations has helped us think through how to best focus those investments to maximize support for naval operations in the future. We are coordinating closely with the initiatives that OSD, Air Force and DARPA have in this area.

Marine Mammals and the Environment

A significant S&T effort is dedicated to effective and responsible stewardship of the marine environment, and this specifically includes the impact of national security requirements and activities on fish and marine mammals. Navy is the worldwide leader in marine-mammal research, with ONR spending approximately $13 million annually on research to understand how marine mammals may be affected by sound. Total Navy investments represent a majority of the dollars spent on this research in the U.S., and nearly half spent worldwide.

As I reported last year, the Navy collaborates with universities, institutes, industry, conservation agencies, and independent researchers around the world to better understand what combinations of ocean conditions, geography, and sonar usage could potentially impact marine mammals and the environment. Congress has been generous in support of these programs and I look forward to continued partnership in achieving the goal of better protecting the marine environment.

Notable progress was made last year and we are accelerating investments in this research in FY 2008 and 2009. We are specifically leveraging the capabilities for Marine Mammal Monitoring on Ranges (M3R) at the Atlantic Undersea Test and Evaluation Center (AUTEC), by taking advantage of that resource in our Behavioral Response Study. In addition we are exploring use of radar and autonomous underwater gliders equipped with hydrophones to detect marine mammals in our Accelerated Monitoring Technologies program, with the goal of improved detection of marine mammals over current methods without interfering with training realism both on and off range.

Understanding the Sea

We are a Service of the Sea and must continue to research and understand the marine environment to better understand how to use it to support Naval missions. 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 the academic oceanographers.

The FY 2009 Budget request continues that partnership with the next generation of Ocean Class research vessels. It funds a Phase I award for the Functional Design by the Program Executive Office (PEO) Ships. This will support a planned Phase II award in FY 2011 to start construction of the lead ship with planned delivery in FY 2014.

Conclusion

I want to thank you again for the opportunity to discuss initiatives undertaken by Naval S&T and your Navy/Marine Corps team and for your strong support of our effort in the past. The FY 2009 President's Budget request is about both prevailing in today's wartime environment and bridging to a strong, flexible, and pre-eminent Naval force in the future. Building that bridge requires careful S&T investments that will protect this nation and our war fighters long into the future.

In executing the S&T Strategic Plan, we must monitor, assess and leverage emerging S&T in a global environment. The worldwide movement of technology and innovation demands that we be able to take advantage of emerging ideas and science wherever they originate, and we have an aggressive worldwide presence to ensure we do just that.

We continue to focus the majority of our investment on external performers – those 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).

Investments must be balanced between long range discoveries from Basic Research and near term products of 6.3 programs. We must ensure the S&T well remains deep in support of the next generations of Sailors and Marines, while focusing on transition of innovative concepts and technology to today's warfighters – all at the same time. S&T is not an end in itself, but a means to the end of supporting our Sailors and Marines today and in the future.

We have a near term focus on Iraq and Afghanistan and a long term focus on strengthening the Navy and Marine Corps ability to meet any challenge in any security environment. We are moving toward greater integration of capabilities, more effective partnership between research and acquisition worlds, and a broader vision of how to achieve shared goals with DARPA, Army and Air Force research organizations. This is evidenced by the Navy S&T Strategic Plan, by real increases in the President's FY 2009 S&T budget, and by the fact that approximately 10% of our portfolio involves ONR partnerships with these and other organizations.

I believe the state of our S&T investments is sound, represents careful stewardship of taxpayer dollars, and will make significant contributions to our war fighters as they serve in defense of the United States, both today and in the future. Thank you again for your support.

DEPARTMENT OF THE AIR FORCE

PRESENTATION TO THE HOUSE ARMED SERVICES COMMITTEE

SUBCOMMITTEE ON TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES

UNITED STATES HOUSE OF REPRESENTATIVES

SUBJECT: Fiscal Year 2009 Air Force Science and Technology

STATEMENT OF: Mr. Terry J. Jaggers, SES
Deputy Assistant Secretary
(Science, Technology and Engineering)

March 13, 2007

NOT FOR PUBLICATION UNTIL RELEASED
BY THE ARMED SERVICES COMMITTEE,
UNITED STATES HOUSE OF REPRESENTATIVES

INTRODUCTION

Mr. Chairman, Members of the Subcommittee, and Staff, I am pleased to have the opportunity to provide testimony on the Fiscal Year 2009 Air Force Science and Technology (S&T) Program. Last year, I spoke extensively about adapting Air Force S&T to the new security environment identified in the Quadrennial Defense Review. Recall, I presented our new AF S&T vision – to Anticipate…Find, Fix, Track, Target, Engage, and Assess…Anything, Anytime, Anywhere – as our guide for shifting investment emphasis from traditional conventional threats to address new threats, such as terrorism. I am proud to say that this budget continues to reflect a shift towards this new security environment.

The Air Force Fiscal Year 2009 President's Budget request for S&T is approximately $2.1 billion, which includes $1.9 billion in "core" S&T efforts with the remaining funds supporting devolved programs to include 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 $157 million or 6.7 percent real growth over the Fiscal Year 2008 "core" request. Even taking the $40 million of Manufacturing Technology (ManTech) funding that was moved into S&T out of the equation, this still represents a very healthy 4.5 percent real growth and reflects the continued strong support of Air Force leadership for its S&T Program.

AIR FORCE GUIDING PRINCIPLES FOR S&T

In 2005, I established five guiding principles for the Air Force S&T Investment Program: Value Our People; Balance the Portfolio; Focus Investments; Honor Commitments; and Transition Technology. These principles have provided a valuable framework for oversight of the S&T program and align well with Air Force and Department of Defense strategic priorities.

The following provides some highlights of our recent accomplishments and initiatives for the coming budget year.

VALUE PEOPLE

Developing, recognizing, and ensuring competent technical intellectual capital exists in the laboratory and elsewhere across the Air Force is my number one guiding principle. As Functional Manager for the 15,000 Scientists and Engineers (S&Es) across the Air Force, my commitment to develop and care for the 3,300 S&E Airmen in our laboratory is paramount to maintaining our competitive advantage. This commitment is reflected in our use of the various flexibilities afforded the Air Force under the Laboratory Personnel Demonstration program or Lab Demo. Additionally, my S&E development teams are creating new leadership development tools and initiatives to vector laboratory S&Es into appropriate career paths necessary to ensure future Air Force technical leaders for years to come. In fact, I had the great honor of formally recognizing 33 of our top S&Es (22 of which came from the laboratory) at a recent ceremony as true leaders and pioneers of science, technology, and engineering advancements in the Air Force. Critical to building our nation's intellectual capital and supporting the growth of future Air Force technical leaders, we continue to leverage the National Defense Science and Engineering Graduate Scholarship and the National Defense Education Programs. We also leverage the Science Mathematics and Research for Transformation program to educate and recruit undergraduate and graduate students. We have selected 48 individuals for this scholarship program since 2005 – all are still in the program with the exception of five who have graduated and were placed in Air Force positions. Additionally, I recently initiated a study with the National Research Council (NRC) to address our science, technology, engineering and mathematics (STEM) requirements in the Air Force, to ensure we are adequately positioned to meet the three priorities identified in our Air Force Strategic Plan. We expect this study to finish later this year and, in concert with the NRC, look forward to presenting the results to you.

Finally, we continue to incorporate good ideas from our people into our processes through the Secretary's Air Force Smart Operations for the 21st Century Initiative. This initiative is a relentless pursuit of process excellence and our S&E workforce is heavily involved from the laboratory, to product centers, to test and sustainment centers. Mindful of the future, the Air Force will continue to make our tech workforce a top priority and will strengthen our efforts to recruit and retain the best technical talent the Nation has to offer.

BALANCE THE PORTFOLIO

My second guiding principle is to ensure a balanced portfolio investment between near-, mid-, and far-term needs. The proportion of 6.1 to 6.2 to 6.3 in the S&T portfolio is largely driven by history and has served us well; however, we are currently aligning the portfolio to the Air Force Strategic Plan to assess this balance. At present, to ensure our far-term needs are met, we allocate no less than 15 percent of our core portfolio to our 6.1, basic research efforts to make certain we bring to bear the most innovative thoughts and push technology in areas to which we have not even defined the problem or concept of operation. This research is targeted toward the Air Force's most challenging technical problems through the support of universities, industry, and the Air Force Research Laboratory (AFRL). To meet near-term needs, our goal is to allocate no less than 30 percent of the portfolio to 6.3, advanced technology development efforts to facilitate mature technology transition opportunities for modernization and support to the warfighter in ongoing conflicts. Keeping the right balance is always a challenge, and we continually assess these goals to ensure the right investment is in place to respond quickly to the threats of today and anticipate those of tomorrow.

FOCUS INVESTMENTS

My third guiding principle is to focus our resources on things that matter most – winning the global war on terror, providing modernized capabilities to warfighters, and providing technologies to ensure enduring aerospace power for the Nation. This budget focuses investments to demonstrate and deliver technologies to address all three. We continue to build on our new planning framework called Focused Long-Term Challenges, which is linked through our S&T vision to Air Force strategic priorities.

First, we shifted investments in traditional areas to support the global war on terror, as defined by our Air Force tech vision to anticipate enemy actions, and to tag, track and locate them anywhere on the globe, 24 x 7...a universal situational awareness. Our goal is to develop a layered and flexible sensing architecture that responds to the Commander's intent by anticipating, detecting, continuously tracking, identifying, and precisely locating high value difficult targets. As you may know, we rapidly developed the Angel Fire electro-optical staring array, which deployed with the Marine Corps to theater to support ongoing operations. Angel Fire is an airborne wide-area (city-sized), image gathering, persistent electro-optical sensor array that distributes real-time imagery straight to the warfighter. To improve on Angel Fire capabilities, we increased investment in an all-weather, day-night persistent intelligence, surveillance, and reconnaissance (ISR) technology called the GOTCHA Synthetic Aperture Radar. And, for those times when overhead surveillance is ill-suited or requires augmentation, we also increased investment in bio-taggants. The use of these new bio-taggants could revolutionize our ability to track weapons of mass destruction around the globe. Bio-taggants attach either a passive identifying material (or taggant) to a biological warfare agent that can then be read by line-of-sight spectroscopy, or an active taggant that is activated by radio frequency energy so it can be read through walls.

Next, we shifted investments to increase focus on game changing technologies to guarantee modernized systems have technological superiority on the battlefield, while ensuring preeminent national aerospace power in the areas of cyberspace, defensive counterspace, directed energy, alternative fuels, revolutionary propulsion, and composites. For instance, we have a Cyber Situational Awareness display effort under development that will alert operators to anomalies or intrusions into a network and will anticipate an adversary's next cyber move. The goal is not to wait until after a cyber attack occurs and then analyze what happened, but to examine what is happening in real-time and provide feedback to adaptive defense measures to permit us to "fight through" any attack. The technologies we are developing will provide our new Cyber Command with similar capabilities as those developed for conventional Air Force employment, such as strike or reconnaissance systems.

We continue to conduct research and develop technologies for responsive access and operation in space. Defensive counterspace activities have received increased investment in this year's budget and the Air Force is working to provide technologies to detect, understand, and mitigate the threats in the space environment across the full-range of natural and man-made sources. Such technologies could include real-time proximity sensing, threat warning, nuclear detonation remediation, and survivable space electronics. These technologies enable protection of high value assets from space- and ground-based threats, and create capabilities to retain U.S. freedom of action in space. The ability 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 are all prevalent space situational awareness concerns. One such nanosatellite project currently underway is investigating methods to provide a responsive space situational awareness capability to characterize objects at geostationary orbits. We are also investigating smaller, plug-and-play types of satellites that offer more responsive construction and launch options, such as conventional air-launched missiles. Our microsatellite activities have led to new satellite acquisition concepts, leveraging small satellites to deliver essential capability to the warfighter faster. An example of such capabilities is the Tactical Satellite-2 (TacSat-2) that launched on December 16, 2006. TacSat-2 successfully demonstrated rapid space launch procurement and employment, rapid reaction tactical operation, and autonomous mission operations, planning, and data distribution – capabilities that will link the ultimate high-ground closer to the tactical warfighter.

As with space situational awareness, directed energy is seen as a game changer. Our directed energy activities plan to deliver precision effects for the warfighter, and include various technologies, both near- and far-term, that will create new Air Force applications and missions. Increased investment in directed energy technologies include solid state lasers paving the way for high energy lasers in small- to medium-sized platforms for offensive and defensive applications, and high power microwave devices and antennas for non-lethal covert electronic attack. The Air Force is currently developing and demonstrating the enabling component technologies required for an airborne non-lethal directed energy weapon. Efforts will continue to refine existing beam control and antenna concepts to meet airborne requirements. Supporting technologies, such as new materials for power and millimeter wave sources, and multi-megawatt, lightweight power generation for these potential directed energy devices, are also being developed. Development and transition of these innovative directed energy technologies provide our warfighters with the best capabilities to defeat the enemy in this new era of irregular warfare.

Rapid global engagement is critical to delivering precision effects, and the Air Force has increased investment in alternative fuels and revolutionary propulsion technologies in response. The Air Force spends more than $10 million per day on aviation fuel and this is the main reason we are evaluating different fuel sources to reduce the Department of Defense's (DoD's) dependence on foreign oil. We are currently leading the evaluation of alternative fuels and engine technologies that may lead to greater fuel efficiency and significantly reduce our dependence on oil. The Air Force is qualifying synthetic fuel based on a domestic source to ensure a stable energy supply regardless of political uncertainties in oil-producing countries or supply disruptions. As a result, we continue to certify Fischer-Tropsch (F-T) fuel for military aviation use. The Air Force successfully certified the B-52 to use a blend of JP-5 and a synthetic fuel derived from natural gas using this F-T process. The Air Force is also looking at other ways to increase aircraft fuel efficiency, including advanced computational fluid dynamics tools to improve aircraft design optimization and reduce drag, as well as exploring lighter aircraft structures. In addition, the Highly Efficient Embedded Turbine Engine project is developing fuel efficient engine technologies that support future ISR, tanker, mobility, manned, and unmanned combat air vehicle missions with extreme endurance and range requirements.

Influenced by an NRC aerospace propulsion study, we increased investments in revolutionary propulsion projects promoting engine efficiency and performance such as the Adaptive Versatile Engine Technology (ADVENT) project. ADVENT is a variable-bypass ratio turbofan engine technology concept that allows efficient engine operation at both subsonic and supersonic speeds. It provides supercruise thrust without after-burner, all using a fixed inlet and/or fixed exhaust configuration. Revolutionary propulsion activities also include technologies in hypersonics and long-range strike platforms. Our X-51 Scramjet Engine Demonstration project plans to provide the hypersonic propulsion needed for an affordable, fast reaction, stand off weapon. This technology could allow rapid response to time-sensitive or deeply buried targets at long range, while reducing vulnerability to enemy air defenses.

In response to a Scientific Advisory Board study, we increased investment in critical thermal management technologies. Thermal loads are growing in our increasingly complex weapon systems, while available heat sinks remain the same. Seeing this manifest itself in existing weapon systems, we have increased investments to find technology solutions in high heat sink fuels, advanced materials, and other heat rejection/reduction/energy extraction systems to avoid this problem in future systems.

All of the military capabilities that might be brought to bear in conflict are of little value if forces cannot gain access to or survive in the battlespace, whether it is air, space, or cyberspace. Operating manned aircraft safely in the same air space with increasing numbers of unmanned aerial vehicles (UAVs) of all sizes has become a greater concern. To address this issue, we are currently developing advanced flight control automation and adaptive algorithms for UAVs, photonic sensing and flight control, and joint air space management and deconfliction software. Breakthroughs in these "sense and avoid" technologies for UAVs have a multiplier effect, in that sense and avoid technologies certified for use by the Federal Aviation Administration in domestic airspace could have positive impacts on the military UAV industrial base leading to increases in innovation and costs through a market that includes both military and commercial customers.

Of course, our strong commitment to composite aircraft structures, materials, and manufacturing techniques continues. We have increased emphasis in composites for the use and sustainment of aircraft, specifically in the area of hybrid composites. Hybrids provide the best of both worlds combining the strength of metals with the lighter weight of composites. We continue to identify and allocate a portion of the portfolio to the development of tools, training, and advanced composites knowledge transfer to enable the government product and logistics center workforce to work with composites in the future. In addition to composites, we feel there are many advances to make in the sustainment area and we are pursuing technologies to embed health monitoring capabilities into our systems to increase readiness, reliability, and maintainability, while reducing costs. We are also developing, characterizing, and demonstrating structural hybrid materials and strategies to protect against enemy radar detection and enable low-observable, integrated antenna, and lightweight radar applications. These technologies enable protection from threats, while maintaining full mission capability.

Guided by our S&T vision, we have focused our investments to support the Air Force strategic priorities to win the global war on terror, provide modernized capabilities to warfighters, and provide technologies that ensure enduring aerospace power for the Nation.

HONOR COMMITMENTS

Honoring commitments is my fourth guiding principle. We are committed to leveraging and synergizing our S&T investment through Memoranda of Agreements (MOA) and similar commitments with our sister Services and Defense Agency partners, such as an MOA with the Defense Advanced Research Projects Agency for embedded engine health monitoring and prognosis. Our commitment to the Office of the Secretary of Defense's new Reliance 21 process provides an improved avenue for the Services and Defense Agencies to benefit from each other's S&T investments and we welcome this collaboration. This year, under the new Reliance 21 process, we have opened our previously internal Air Force S&T reviews to the entire DoD S&T enterprise and are setting the standard for collaboration across the Department. We are also committed to the new Reliance 21 Technology Focus Team concept. These teams closely examine select technology areas and are charged with identifying S&T gaps or opportunities in delivering technologies to meet DoD capability needs.

We value and protect our commitments to our international allies and the North Atlantic Treaty Organization as well. One example is our collaboration with the Australians on the Hypersonics International Flight Research and Experimentation project in which Flight 1 is scheduled to take place later this year at the Woomera Test Range in Australia.

Industry partnerships for mutual DoD-commercial interests, such as the Versatile, Affordable Advanced Turbine Engine (VAATE) program, provide innovative cost-share relationships with industry and other agencies, such as the Department of Energy. We have also strengthened our commitment to, and communications with, industry with regards to independent research and development by creating a new Air Force/industry interchange process. We are conducting industry days and technical interchange meetings to align and coordinate our technology development and needs with industry's research and development activities. Whether our commitments are with others in the Air Force, our sister Services and Defense Agencies, the Office of the Secretary of Defense, industry, our allies, or Congress...you have my word that we will deliver on our commitments.

TRANSITION TECHNOLOGY

Last, but not least of my guiding principles is to find new and improved ways of transitioning technologies directly to the warfighter in the field, or into our weapon system acquisitions. I am proud to say that this year; we are establishing a new Technology Transition Office within Headquarters Air Force to spear-head and focus this effort for the Air Force Acquisition Executive. The focus of this office is on developing and implementing policies to overcome transition obstacles and facilitate the transition of technology in support of new concepts, programs of record, and fielded systems. It serves as a central focal point for addressing inquiries and proposals in this important area, creating synergy in technology transition efforts that will more efficiently match solutions to needs, and revitalizing requirements planning and technology maturation. This office is also responsible for investigating activities to reduce risk to acquisition programs through improved requirements evaluation, increased prototyping, and focused technology maturation for timely insertion into programs of record.

The Air Force recently transitioned responsibility for the Joint Capability Technology Demonstrations (JCTD) management into this office, which provides us with huge opportunities for tech transition synergy. One success story involves transition of weapon technologies into a JCTD project called Focused Lethality Munition (FLM). Conventional bombs pose risks for civilian casualties and infrastructure damage in urban environments. The FLM project provides a highly localized lethal footprint to support military operations in urban terrain. This is truly an example of synergizing S&T and JCTD investments to make a difference.

The Technology Transition Office is also responsible for monitoring the transition of the Laboratory's Advanced Technology Demonstrations (ATDs). And, while the ATD process involves a more evolutionary transition of technologies in conjunction with the budget timelines, we are in the process of codifying a new process for the Air Force to rapidly deliver S&T capability to warfighters within months rather than years. A recent success with this process involves an operational prototype Space Situational Awareness system that was developed and delivered to the Joint Space Operations Center (JSpOC). This system called JSpOC Situation Awareness and Response System utilizes existing space weather data, satellite telemetry, ephemeris data, and engineering information about satellites to provide a rapid visual indication of the space situation and an assessment of abnormal activities or events.

In addition, our efforts in the Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) and ManTech programs are further examples of programs where we are seeking to improve technology transition. The Air Force appreciates the opportunity provided by Congressional direction authorizing the SBIR Commercialization Pilot Program and we are well on our way to making this program a huge success. We have developed a more strategic topic generation process aligned with customer technology challenges to increase the likelihood of transitioning SBIR technologies and products. We have collocated SBIR representatives with our customers to assist in this process, thanks to the Commercialization Pilot Program.

Lastly, the strength and effectiveness of Air Force warfighting capability depends on our ability to ensure the industrial base is poised to be responsive to our warfighting needs. We recently addressed an industrial base issue that involves Lithium Ion cells, which are increasingly used as a preferred source for batteries in many U.S. Government defense, intelligence, and civil aerospace applications. Lithium Ion technology is particularly advantageous to space applications, since it offers to reduce battery mass by as much as one-half and volume by two-thirds, when compared to state-of-the-art nickel hydrogen technology. In an effort to address growing concerns over the future supply of Lithium Ion cells in the national technology and industrial base, we are partnering with other government agencies to jointly fund and manage a collaborative effort for the development of a space Lithium Ion battery capability. The goal of the effort will be to establish an assured source for space quality Li-Ion battery cells and associated critical materials for space applications as part of the national technology and industrial base.

Coupling these activities with a focus on more disciplined Systems Engineering in the pre-acquisition planning phases is strengthening the Air Force transition process, resulting in acquisition programs with the latest technology and more mature technical planning.

CONCLUSION

The Air Force S&T Program has a rich legacy of developing technologies that support warfighting capabilities. History clearly demonstrates the broad benefits to the Air Force of our S&T efforts in terms of military power, industrial capability, economic growth, educational richness, cultural wealth, and national prestige. The Air Force continues to maintain a diverse and ambitious S&T portfolio. The Air Force S&T Program researches, develops, and demonstrates technologies that could be used in a number of different warfighter applications. Our technology vision – to Anticipate…Find, Fix, Track, Target, Engage, and

Assess...Anything, Anytime, Anywhere – guides us in our efforts to address the spectrum of threats the 21st Century brings with it.

The Air Force S&T Program is in direct support of the Air Force strategic priorities to win the war on terror, while preparing for the next war; develop and care for Airmen to maintain our competitive advantage; and recapitalize and modernize our aircraft, satellites, and equipment to optimize the military utility of our systems and better meet 21st Century challenges. Our Fiscal Year 2009 budget builds on past S&T successes and a future technical vision with a clear focus on the new security environment. Today's Air Force leaders have shown their commitment in supporting an Air Force S&T Program that has served the Air Force well for over sixty years. This commitment is clearly shown through the Air Force Fiscal Year 2009 President's Budget request of over $2 billion. The Air Force S&T Program is in a time of great change as we reshape our S&E workforce, address the new security environment through a capability-based planning construct, retool our processes under the Secretary's Air Force Smart Operations for the 21st Century Initiative, understand the S&T needed in support of the new Cyber Command, and tackle technology transition and manufacturing issues. Despite the challenges facing us in Air Force S&T, we will continue to focus and protect our S&T investments to advance the state-of-the-art in areas critical to our continued dominance of air, space, and cyberspace.

Mr. Chairman, 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

Dr. Tony Tether

Director
Defense Advanced Research Projects Agency

Submitted to the

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

March 13, 2008

NOT FOR PUBLICATION UNTIL RELEASED BY THE SUBCOMMITTEE

Mr. Chairman, Subcommittee Members and staff: I am pleased to appear before you today to discuss the Defense Advanced Research Projects Agency's (DARPA) ongoing activities, and our Fiscal Year (FY) 2009 plans to continue as the engine for radical innovation in the Department of Defense (DoD).

DARPA is 50 years old as of February 7. DARPA's original mission, by the Soviet Union beating the United States into space with Sputnik in October 1958, was to prevent technological surprise. This mission has evolved over time. Today, DARPA's mission is to prevent technological surprise for us *and* to create technological surprise for our adversaries. Stealth is one example of how we created technological surprise.

DARPA conducts its mission by searching worldwide for revolutionary high-payoff ideas and then sponsoring research projects that bridge the gap between fundamental discoveries and their military use.

DARPA is the Department of Defense's only research agency not tied to a specific operational mission: DARPA supplies technological options for the entire Department and is designed to be a specialized "technological engine" for transforming DoD.

This is a unique role within DoD. The Department's operational components naturally tend to focus on the near term because they must meet urgent needs and requirements. Consequently, a large organization like DoD needs a place like DARPA whose only charter is radical innovation.

The DARPA Model

DARPA's mission is fairly easy to understand. In recent years, DARPA's success has inspired efforts to replicate DARPA at other Federal agencies – notably in the Department of Homeland Security, Department of Energy, Department of Health and Human Services, and in the Intelligence Community. So the questions become, "How does DARPA do it? What are the features of DARPA that have made it so successful in its mission?"

A little over a year ago, an article appeared in *The American Interest*[1] that did a good job of capturing what makes DARPA DARPA. Borrowing and adapting from that work, here are some key characteristics to keep in mind when trying to set up something like DARPA elsewhere:

- *Small and flexible*: DARPA has only about 140 technical professionals; some have referred to DARPA as "100 geniuses connected by a travel agent."
- *Flat organization*: DARPA avoids hierarchy, essentially operating at only two management levels to ensure the free and rapid flow of information and ideas, and rapid decision-making.
- *Autonomy and freedom from bureaucratic impediments*: DARPA has an exemption from Title V civilian personnel specifications, which provides for a direct hiring authority to hire talent with the expediency not allowed by the standard civil service process.
- *Eclectic, world-class technical staff and performers*: DARPA seeks great talent and ideas from industry, universities, government laboratories, and individuals, mixing disciplines and theoretical and experimental strengths. DARPA neither owns nor operates any laboratories or facilities, and the overwhelming majority of the research it sponsors is done in industry and universities. Very little of DARPA's research is performed at government labs.
- *Teams and networks*: At its very best, DARPA creates and sustains great teams of researchers from different disciplines that collaborate and share in the teams' advances.
- *Hiring continuity and change*: DARPA's technical staff is hired or assigned for four to six years. Like any strong organization, DARPA mixes experience and change. It retains a base of experienced experts – its Office Directors and support staff – who are knowledgeable about DoD. The staff is rotated to ensure fresh thinking and perspectives, and to have room to bring technical staff from new areas into DARPA. It also allows the program managers to be bold and not fear failure.
- *Project-based assignments organized around a challenge model*: DARPA organizes a significant part of its portfolio around specific technology challenges. It foresees new innovation-based capabilities and then works back to the fundamental breakthroughs required to make them possible. Although individual projects typically last three to five years, major technological challenges may be addressed over longer time periods, ensuring patient investment on a series of focused steps and keeping teams together for ongoing collaboration. Continued funding for DARPA projects is based on passing specific milestones, sometimes called "go/no-go's."
- *Outsourced support personnel*: DARPA extensively leverages technical, contracting, and administrative services from other DoD agencies and branches of the military. This provides DARPA the flexibility to get into and out of an area without the burden of sustaining staff, while building cooperative alliances with its "agents." These outside agents help create a constituency in their respective organizations for adopting the technology.

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1 "Power Play," W. B. Bonvillian, *The American Interest*, Volume II, p 39 (November-December 2006).

- *Outstanding program managers*: The best DARPA program managers have always been freewheeling zealots in pursuit of their goals. The Director's most important task is to recruit and hire very creative people with big ideas, and empower them.
- *Acceptance of failure*: DARPA pursues breakthrough opportunities and is very tolerant of technical failure if the payoff from success will be great enough.
- *Orientation to revolutionary breakthroughs in a connected approach*: DARPA historically has focused not on incremental but radical innovation. It emphasizes high-risk investment, moves from fundamental technological advances to prototyping, and then hands off the system development and production to the military services or the commercial sector.
- *Mix of connected collaborators*: DARPA typically builds strong teams and networks of collaborators, bringing in a range of technical expertise and applicable disciplines, and involving university researchers and technology firms that are often not significant defense contractors or beltway consultants.

We cannot claim to have been so wise as to have invented this entire model all up-front. In fact, it evolved over time in response to various conditions and constraints DARPA has faced over the years. But it works quite well for us, and is a major contributor to our success.

Because, in many ways, DARPA operates quite differently from the rest of the government, it can be easy to inadvertently damage our approach.

For example, we are sometimes asked why DARPA's annual obligation rates are not higher in the midst of a fiscal year. As you may know, there is a constant push on Federal agencies to obligate their money as quickly as possible during the fiscal year – the fiscal motto being, "Use it or lose it." However, DARPA takes a different approach. Rather than rush to obligate money at the beginning of a fiscal year, DARPA holds funds until performers pass significant, agreed-upon milestones – their "go/no-go's." This keeps people highly motivated, but it can also artificially make our obligation rates look lower than they really are during a fiscal year, which raises eyebrows and makes us a target for budget cuts because of "poor financial execution." But we think our approach results in better technical management because it is focused on performance-based results, rather than financial imperatives.

Also, last year there were some proposals in Congress to augment the post-employment restrictions on Federal employees. While well-intentioned, these kinds of moves could harm an organization like DARPA. Consider this from the point of view of the world-class technical talent that DARPA wants to recruit, many of whom may take a salary cut to join us. They know they will only be with DARPA for four to six years, and they would like their careers to continue to flourish when they leave us. If they believe it will be more difficult to find a job in their field after they leave DARPA, that will tend to discourage them from joining us in the first place.

My point here is simply that DARPA's model – which has been very successful, and which people would like to replicate elsewhere – is different from almost all other government organizations. If DARPA is to remain successful, its unique business processes must be protected.

DARPA's Outreach

Because DARPA works on "blue-sky" projects, it is easy to believe that we are off by ourselves without much contact with other organizations. It's not like that at all.

We put a tremendous amount of energy into outreach to two different groups. One group might be called our "customers." These are people within DoD who have difficult operational challenges that need to be solved, or whom we need to convince to try a new technology. We need to understand their operational challenges and eventually market new technologies to them. Just over this past year alone, we have briefed several DoD leaders on our efforts and obtained their direct feedback. The individuals we have briefed include:

- Deputy Secretary of Defense, Mr. Gordon R. England
- Secretary of the Army, Mr. Pete Geren
- Vice Chairman, Joint Chiefs of Staff, General James E. Cartwright
- Commandant of the Marine Corps, General James T. Conway
- Commander, U.S. Southern Command, Admiral James Stavridis
- Commander, U.S. Special Operations Command, Admiral Eric Olson
- Under Secretary of the Air Force, Dr. Ronald M. Sega
- General Counsel of the Department of Defense, Mr. William J. Haynes II
- Commander, Air Force Space Command, General Kevin P. Chilton
- Commander, Air Combat Command, General John D. W. Corley
- Commander, Air Combat Command, General Ronald Keys
- Commander, U.S. Army Training and Doctrine Command, General William S. Wallace
- Deputy Under Secretary of Defense, Advanced Systems and Concepts, Mr. John Kubricky
- Director, Missile Defense Agency, Lieutenant General Henry A. Obering III
- Director, National Security Agency/Chief, Central Security Service, Lieutenant General Keith B. Alexander
- Commander, Marine Corps Combat Development Command, Lieutenant General James F. Amos
- Surgeon General of the Air Force, Lieutenant General James G. Roudebush
- Commander, U.S. Army Medical Research and Material Command, Major General George Weightman
- Commander, U.S. Submarine Forces, Vice Admiral John J. Donnelly
- Deputy Director, Strategy and Policy, J-5, Rear Admiral Frank Pandolfe

- Deputy Surgeon General of the Navy, Rear Admiral Thomas R. Cullison
- Special Assistant for Undersea Strategy, Rear Admiral Winford Ellis
- Defense Liaison Office N87, Rear Admiral Joseph Enright
- Administrator, National Aeronautics and Space Administration, Dr. Michael Griffin
- Director for Defense Procurement and Acquisition Policy and Strategic Sourcing, Mr. Shay Assad
- Deputy Director, National Security Agency, Mr. Chris Inglis

The other group is what one might call our "suppliers." DARPA does not conduct any research on its own. Instead, we sponsor other people – primarily in industry and academia – to do the research and create new technologies. So we ultimately depend on good ideas well executed by others. We need to reach those people, get their ideas, and carry those ideas forward.

To reach out to our customers within DoD, we have a group of people we call our Operational Liaisons. These are senior military officers from the Army, Navy, Air Force, and Marine Corps who keep us well connected to problems within the Services. They help us understand the operational challenges, and are also instrumental in transitioning our technologies to the Services. Essentially, they bring problems in and take solutions out. We also have individuals assigned to DARPA from other DoD agencies: the National Geospatial-Intelligence Agency, Defense Information Systems Agency, and National Security Agency – and a special assistant who works full-time on developing strategies and plans for technology transitions.

As a particular focus for our outreach, we have an individual assigned full-time to U.S. Special Operations Command (USSOCOM), so that we can use USSOCOM as our real-world laboratory, and they, in turn, use DARPA for experimental technologies.

In addition, we have junior officers who come to DARPA on short-term assignments. These officers help us understand what's going on in the various Services and forge connections at the working level. But more importantly, we are building relationships so that when they become senior officers they will know how to use DARPA to effectively solve future operational challenges.

Our senior management team takes trips to visit our forces in the field to get a better, hands-on "feel" for their operational challenges. For example, in January we took a trip to U.S. Southern Command to get a much better idea of the Joint Task Force's counter-narcotics operations. As a result of the visit, we are recommending DARPA-developed technologies in surveillance and tracking, information displays, and vessel inspection, which could help improve the Task Force effectiveness.

The other part of our outreach effort is to connect with innovative researchers wherever they are. So we are constantly trying to find people with great ideas, and help people with great ideas find us.

Our signature event for this is DARPATech, a technical conference where we lay out our vision of the future for the research community and discuss technical problems and opportunities. The goal is to spur people to develop bold ideas that lead to great proposals, great projects, and ultimately the best technology for our warfighters.

The most recent DARPATech was held last August in Anaheim, California. It was our largest event ever, attracting over 3000 attendees. We held almost 1000 "sidebars" in which individuals could discuss their ideas with DARPA program managers in short, private meetings. As a result of DARPATech, we received many new ideas for programs that could lead to important new capabilities for DoD.

Major Progress Since 2001 – and More to Come!

Since 2001, DARPA has accomplished a great deal for our national security. To describe the enormous progress we have made across a wide swath of technology and our plans to continue that progress, let me just highlight eight broad areas.

The eight areas are:

- Deny hiding in any environment and cultural background;
- Provide persistent situational awareness and rapid strike;
- Beat the OODA (observe-orient-decide-act) loop of modern adversaries;
- Provide cyber operations dominance;
- Remove the value of using biological weapons;
- Increase survival from life-threatening wounds;
- Restore injured warfighters to the way they were; and
- Develop core technologies that maintain U.S. military superiority.

Deny hiding in any environment and cultural background

The U.S. military is incredibly adept at precision strikes against targets on the traditional battlefield. Our adversaries know and understand this, and they are getting smarter about concealing their activities and their movements. DARPA is working to counter these efforts to hide, move, or blend in with the culture and environment by developing technologies to detect enemy activity in all situations and, once adversaries are detected, never to lose track of them.

The first step to finding hidden people and objects is to have good intelligence that cues us about their location. One way to improve our intelligence is to dramatically improve our ability to rapidly translate foreign languages using automated translation technologies. Today, linguists translate important information, but it is a slow and arduous process. We have massive amounts of raw data and not enough linguists to handle the constant streams of information. To manage the enormous quantity of data and intelligence we capture and receive, we must dramatically reduce the growing reliance on linguists at both the strategic and tactical levels by providing revolutionary machine translation capabilities.

The Global Autonomous Language Exploitation (GALE) program is designed to translate and distill foreign language material (e.g., television shows and newspapers) in near real time. The system highlights salient information and stores the results in a searchable database. Through this process, GALE will be able to produce high-quality answers that are normally provided by bilingual intelligence analysts. GALE is working toward fully achieving this ambitious goal by 2010.

Initial capabilities developed in the program were deployed to Iraq in 2006 and 2007. GALE continuously translates Arabic regional news, both speech and text, into English and alerts the warfighter to events of interest and other potentially mission-critical information. GALE is also being used to monitor the reactions of the region's population to current events, promptly capture misinformation/disinformation, and then quickly respond and correct inaccuracies in news reporting. In addition to providing timely translations of Arabic media, GALE systems enable the warfighter to efficiently search and retrieve previously translated information that would otherwise not be readily available.

GALE has continued to dramatically improve the state of the art in machine translation. In the first year, GALE achieved an accuracy rate two times better than was thought possible, and the program is continuing these strong technological advancements. Overall, GALE's translation of structured speech and text (e.g., broadcast news and newswire) has improved to the point that it produces "edit-worthy" text. This saves time, since it is more efficient for a translator to edit the GALE product directly, as opposed to retranslating the original material.

The success of the GALE technology is making it possible to automate the exploitation of hard-copy documents and text images under our new Multilingual Automatic Document Classification Analysis and Translation Exploitation program.

At the tactical level, there are not enough translators for each patrol or vehicle checkpoint. Our warfighters also need automatic, on-the-spot speech translation to work with Iraqi units and so they can quickly use what they might be told by locals about insurgents or suspicious activities.

DARPA's Spoken Language Communication and Translation System for Tactical Use (TRANSTAC) program is working on a two-way speech translation system, a device that converts spoken foreign language input to English output, and vice versa. Such communication systems are indispensable for our troops as they interact with the local population and coalition partners.

Improved intelligence based on faster, more widely available translations can then be coupled with physical sensors to help uncover enemy activities.

For the urban environment, DARPA's Autonomous Real-time Ground Ubiquitous Surveillance – Imaging System (ARGUS-IS) program is developing a new wide field-of-view video sensor to significantly improve the number of targets tracked. The sensor will supply over 65 real-time video windows, each providing high-resolution motion video comparable to that currently provided by Predator. Each window will also be independently steerable, allowing operators to keep critical areas of interest under constant surveillance. ARGUS-IS is designed to operate on the A160, a revolutionary high-altitude, long-endurance, unmanned helicopter.

And for operations in forested areas, last year we successfully demonstrated a foliage penetrating radar that detects vehicles and dismounted adversaries under heavy forest canopy. The radar, called FOPEN Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER), was installed on a Black Hawk helicopter and flew at a standoff range. Operators onboard the aircraft could detect people walking under foliage in and around concealed encampments. This year we also plan to install and demonstrate this radar on the A160.

The Synthetic Aperture Ladar for Tactical Imaging (SALTI) program will develop and demonstrate an airborne synthetic advanced laser radar (ladar) imager capable of producing high-resolution, three-dimensional imagery at extended ranges. For deployment within a tactical-sized package, SALTI will combine the long-range day/night access of conventional synthetic aperture radar with the interpretability of high-resolution optical imagery and exploitability of three-dimensional imagery. The program will demonstrate full operation at tactically relevant high altitudes and extended ranges.

DARPA's Integrated Sensor Is Structure (ISIS) program is the most capable U.S. moving target indicator radar for air and ground targets ever conceived and includes foliage-penetration. Using the enormous platform surface area available on a stratospheric airship, ISIS will incorporate an extremely large antenna (approximately 5000 square meters) directly into the structure of the airship. For example, a single ISIS stationed over Baghdad today would provide total airspace knowledge and unprecedented ground vehicle tactical tracking across more than 80 percent of Iraq. Having completed ISIS component development – lightweight/long-life hull material, active electronically scanned aperture X-band/UHF radar, and fully solar-regenerative power system – DARPA is beginning design and manufacture of a scaled demonstration system.

Back on the ground, DARPA's Advanced Soldier Sensor Information System and Technology (ASSIST) program is developing tools to enhance the intelligence-gathering capabilities of our ground troops and help increase the situational awareness for our patrol leaders. The Tactical Ground Reporting (TIGR) system, developed as part of ASSIST, combines sensors, networks, and advanced software so Soldiers can share their observations and experience with ease and accuracy. Details of each patrol and mission are captured in the form of digital photos, videos, GPS tracks, and voice annotations. During mission planning, a patrol leader can quickly tap into TIGR's rich database and analyze recent attacks along all routes, bring up photos and information on the local leaders, census data for the villages, and any other relevant information for the locations that he will be visiting or driving through.

User response has been overwhelmingly positive. TIGR was introduced in Iraq in January 2007, and the users have quickly grown to over 2000 Soldiers across four brigades. An Army lieutenant using TIGR remarked, "A patrol is able to leave the gate knowing all the information needed to accomplish the mission. Seeing what I can know with TIGR, if I had to operate without it, I would feel as if I were in the dark." DARPA is now collaborating with the Army to add key enhancements to TIGR.

Of course, individuals and activities are increasingly being hidden underground. Our Counter-Underground Facility program is developing a variety of sensor technologies and systems – seismic, acoustic, electromagnetic, optical, and chemical – to find, characterize, and conduct post-strike assessments of underground facilities. For example, our Low-Altitude Airborne Sensor System is demonstrating the use of airborne electromagnetic, acoustic, and gravity sensors to rapidly find underground facilities and map out their backbone structure.

In the maritime arena, our Fast Connectivity for Coalitions and Agents (Fast C2AP) program, now complete, developed software agents to allow naval watchstanders to automatically monitor vessels and locate, investigate, and intercept vessels engaged in suspicious activity. Fast C2AP was deployed to both the U.S. Navy's Sixth Fleet and the North Atlantic Treaty Organization's Component Commander-Maritime and was used to identify vessels engaged in illicit behavior. Fast C2AP increases the number of vessels that watchstanders can monitor from tens to thousands per watch, and reduces the time required to obtain detailed information regarding ships from hours to minutes. At the end of 2007, Fast C2AP was transitioned to the Navy.

To support maritime domain awareness, DARPA's Predictive Analysis for Naval Deployment Activities (PANDA) program is developing technology that exploits surface maritime vessel tracks to automatically learn the normal behavior of over 100,000 vessels, and then detect deviations. PANDA will automatically provide alerts on those vessels exhibiting suspicious activity, including activities that have not been previously seen or defined.

Our Collaborative Networked Autonomous Vehicles (CNAV) program is developing improved intelligence, surveillance, and reconnaissance capabilities in littoral waters. CNAV successfully created a self-forming network of unmanned undersea vehicles deployed in a cluttered maritime environment over a two square mile area. These vehicles shared information over a wireless underwater network.

In addition to these systems, DARPA has been working on tagging programs to positively track items of interest. While we cannot discuss most of this work in this forum, I can say a few words about our Dynamic Optical Tags (DOTS) program. DOTS has developed and demonstrated a small, robust, persistent, covert two-way tagging, tracking and locating system that will allow for covert two-way data exchange and tagging operations in friendly and denied areas. DOTS can support data rates greater than 100 kilobits per second up to 10 kilometers, and interrogation angles up to 60 degrees off-axis. In addition, the tags will operate for greater than two months, over a two-year period, in real-world environmental conditions – a capability of great value to our warfighters.

Provide persistent situational awareness and rapid strike

Over the last seven years, DARPA has made great strides toward more responsive and persistent air operations. Our goal is to plan quicker, get there faster, and stay there for a long time.

To plan faster, we are developing cognitive computing technologies that will link key personnel and quickly gather information for them about the target, including the threat, response options, operational forces available, and possible weapons.

Our flagship cognitive computing program is the Personalized Assistant that Learns (PAL), which is developing integrated cognitive systems to act as personalized executive-style assistants to military commanders and decision-makers. PAL is creating a new generation of machine learning technology so information systems can automatically adjust to new environments and new users, help commanders maintain the battle rhythm, and adapt to new situations, priorities and enemy tactics. PAL will also help new personnel come up to speed quickly in command operations, while making more effective use of resources.

PAL technology is being tested at several organizations and activities for possible transition, including U.S. Strategic Command's Strategic Knowledge Integration Web (SKIWeb). Senior military leadership use SKIWeb to share intelligence and to stay abreast of events unfolding throughout the world in real time. SKIWeb uses threaded discussions, or blogging, to share ideas, and encourages collaboration by providing up-to-the-minute situational awareness. PAL learning technology will help SKIWeb recognize and respond to critical event information. Outstanding performance was recently demonstrated in an experiment with real SKIWeb data.

When the U.S. decides to act, we envision using new hypersonic vehicles to quickly reach any point on earth without the need to organize an air refueling tanker fleet to support a long-range mission.

With this vision in mind, DARPA's Falcon program has been working to vastly improve the U.S. capability to promptly reach other points on the globe. A major goal of the program is to flight-test key hypersonic cruise vehicle technologies in a realistic flight environment. Recently we conducted both low- and high-speed wind tunnel tests that validate the stability and control of the hypersonic technology vehicle across the flight regime. The program is also developing a vehicle test bed called Blackswift. By the end of 2012, our goal is for Blackswift to take off under its own turbojet power from a runway, accelerate to Mach 6 under combined turbojet/scramjet propulsion, and land on a runway.

DARPA's Rapid Eye program is working to place a high-altitude, long-endurance platform quickly over any spot on earth. Rapid Eye will create the capability to deliver a persistent intelligence, surveillance, and reconnaissance asset anywhere worldwide within one hour. The program will develop a high-altitude, long-endurance aircraft that can be put on existing space launch systems, withstand atmosphere re-entry, and provide efficient propulsion in a low-oxygen, low-speed environment. Rapid Eye's response time will be hours, not days.

While not hypersonic, DARPA's Oblique Flying Wing program will provide complementary capabilities. Oblique Flying Wing will demonstrate a design concept for a new class of efficient supersonic aircraft capable of flying in a swept configuration with low supersonic wave drag and a non-swept configuration increasing subsonic efficiency. This flexibility will improve range, response time, fuel efficiency, and endurance for supersonic strike, intelligence, surveillance and reconnaissance, and transport missions. The goal of the program is to prove out the stability and control technologies required for an oblique flying wing with an X-plane that will demonstrate an asymmetric, variable sweep, tailless, supersonic flying wing. We have completed the baseline

X-plane design, and we conducted ground-breaking, high-speed wind tunnel testing of a subscale model tailless oblique flying wing last September.

At the tactical level, the Heliplane program will help us quickly reach areas that don't have runways by developing a revolutionary air vehicle that can take-off, land, and hover vertically like a helicopter and cruise with the speed and efficiency of a fixed-wing aircraft. Heliplane offers a two- to three-fold improvement in forward flight characteristics over conventional helicopters. Unlike a helicopter that relies on a rotor for both hover and cruise, the Heliplane adapts lifting mechanisms to achieve high efficiency throughout its flight envelope: a rotor in hover and slow-speed flight and a fixed wing combined with turbofan engines for high-speed flight.

Of course, one key to intelligence, surveillance, and reconnaissance is persistence, which can be enabled by autonomous air refueling or by aircraft that can remain on-station for over five years, for example. Such platforms could be staged in an area of interest and remain there continuously for extended periods of time.

DARPA's Autonomous Airborne Refueling Demonstration (AARD) program developed technologies to perform the complex and dangerous task of midair refueling of unmanned air vehicles (UAVs). Midair refueling would enable new long-range UAV missions with expanded operational envelopes, while reducing the forward basing required for today's generation of unmanned aircraft.

Improved safety and efficiency for manned aircraft is an obvious and important part of AARD. Last year the program successfully demonstrated this technology on a modified F-18, during which the pilot watched the entire operation with his hands and feet off the aircraft's controls. We are currently exploring a range of near-term applications of autonomous refueling to manned fixed-wing aircraft and helicopters, even as we support a broader community that is developing long-range UAVs.

One successful effort to provide airborne persistence has been DARPA's A160 program. The A160 is an unmanned helicopter designed for intelligence, surveillance, and reconnaissance missions with long endurance – up to 18 to 20 hours – and the ability to hover at high altitudes. The A160 concept is being evaluated for surveillance and targeting, communications and data relay, crew recovery, resupply of forces in the field, and special operations missions in support of Army, Navy, Marine Corps, and other needs.

Finally, our Vulture program will develop an aircraft capable of remaining on-station for over five years, pushing technology and design so that the system will not require refueling or maintenance. Our vision reflects a fundamental change in the nature of airborne surveillance – the previously unimagined endurance of a Vulture aircraft will provide a breakthrough in both quality, quantity and timeliness. A single Vulture aircraft could support traditional intelligence, surveillance, and reconnaissance functions over country-sized areas – while at the same time providing an unblinking eye over a critical target, monitoring that target night and day, day in and day out, month after month – providing unprecedented high-value intelligence. Vulture aircraft will also be able to provide communications capabilities available today only from geostationary satellites – offering opportunities for new, more flexible, expandable and relocatable communication architectures at a fraction of the cost of dedicated satellite capabilities. The challenges here include developing solar cell, energy storage, and reliability technologies that will allow the aircraft to operate continuously, unrefueled for over 44,000 hours. The Vulture program will conclude with a year-long flight demonstration with a fully functional payload.

<u>Beat the OODA (observe-orient-decide-act) loop of modern adversaries</u>

Modern warfare means carrying out an "OODA" loop – observe-orient-decide-act – faster than any enemy, which means that we can respond effectively to anything they plan to do, or they cannot respond to anything we want to do. For example, we could disrupt attacks before they can be carried out. One of the promises of network-centric warfare is that it will speed up our OODA loops by making information widely available and fusing the typically separate functions of intelligence and operations. But, of course, network-centric warfare depends on having a *network*. So to really speed up the OODA loop, these networks must not only be effective and robust, but we must be able to set them up quickly – or, better yet, have them be self-forming and self-maintaining.

DARPA has many networking programs to help achieve a vision of linking tactical and strategic users through networks that can automatically and autonomously form, maintain, and protect themselves. We are developing technologies for wireless tactical net-centric warfare that will enable reliable, mobile, secure, self-forming, ad hoc networks among the various echelons that make the most efficient use of available spectrum.

A seminal DARPA tactical networking program, completed a couple years ago, was the Small Unit Operations Situational Awareness System to link together dismounted Soldiers operating in difficult environments such as in cities and forests. This self-forming and self-healing communications network technology transitioned to the Army, where its basic network waveform is being integrated into the Joint Tactical Radio Systems Ground Mobile Radios and the Handheld, Manpack, Small Form Factor Radios.

More recently, to connect different tactical ground, airborne and satellite communications terminals together, our Network Centric Radio System (NCRS) (formerly Future Combat Systems–Communications) program developed a mobile, self-healing ad hoc network gateway approach that provides total radio/network compatibility on-the-move in any terrain – including the urban environment. NCRS has built interoperability into the network itself, rather than having to build it into each radio, so any radio can now be interoperable with any other. Today, using NCRS, previously incompatible tactical radios – military legacy, coalition, and first responder – can talk seamlessly among themselves and to more modern systems, including both military and commercial satellite systems.

This brings me to the frequency spectrum. Most of the spectrum is already allocated to users who may or may not be using it at a given time and place. DARPA's neXt Generation (XG) Communications program has been developing technology to make ten times more spectrum available by taking advantage of spectrum that has been assigned but is not being used at a particular point in time. XG technology senses the spectrum environment in real time and then, in response, dynamically uses spectrum across frequency, space, and time – searching and then using spectrum that is not busy at the moment. XG is designed to resist jamming and not interfere with other users. XG was one of the technologies we displayed in the House Armed Services Committee Hearing Room on January 29.

Building on DARPA's XG and adaptive networking technologies, the Wireless Network after Next (WNaN) program is developing technology and architecture to enable an affordable and rapidly deployable communication system for the tactical edge. The low-cost, highly-capable radio developed by WNaN will provide the military with the capability to communicate with every Soldier and every device at all operational levels. WNaN networking technology will exploit high-volume, commercial components and manufacturing processes so that DoD can affordably and continuously evolve the capability over time. We are working to put this affordable, tactical communications technology into the hands of the warfighter as soon as possible. This was the other technology on display on January 29.

DARPA is also working to bridge strategic and tactical networks with high-speed, high-capacity communications networks. The Department's strategic, high-speed fiber optic network, called the Global Information Grid (GIG), utilizes an integrated network whose data rate is hundreds to thousands of megabits per second. To reach the theater's deployed elements, data on the GIG must be converted into a wireless format for reliable transmission to the various elements and echelons within the theater.

DARPA's Optical and Radio Frequency Combined Link Experiment (ORCLE) program demonstrated a means for relaying GIG information to operational assets at the edge – even if some high data-rate links are degraded by atmospheric or physical obstructions – by teaming high-speed free-space optical communications with high-reliability radio communications. Now, building on this we are planning to design, build, and demonstrate a prototype tactical network connecting ground-based and airborne elements. Our goal is to create a high data rate backbone network via several airborne assets that nominally fly at 25,000 feet and are separated out to ranges of 200 kilometers, which provides GIG services to ground elements up to 50 kilometers away from any one node.

All-optical technology will be essential for ultra-fast strategic networks in the future. A foundation for this will be integrating multiple functions onto a single chip for all-optical routers with highly scalable capacity and throughput. DARPA's Data in the Optical Domain–Network (DOD-N) program has demonstrated a monolithically integrated, compact time buffer with waveguide delays up to 100 nanoseconds. Temporarily storing high-speed data is a critical power-consuming bottleneck for electronic routers, and this first demonstration of an all-optical buffer is a significant step toward overcoming the storage limitations for future data routers.

These networks need to be robust and able to resist disruption. Networks rely on a widely available timing signal, or common clock, to sequence the movement of voice and data traffic. The timing signal is often provided by the Global Positioning System (GPS), and we should expect adversaries to attack our networks by attacking GPS.

To protect these networks, for several years DARPA has been developing a miniature atomic clock – measuring approximately one cubic centimeter – to supply the timing signal should the GPS signal be lost. The Chip-Scale Atomic Clock (CSAC) will allow a network node, such as a Soldier using a Single Channel Ground and Airborne Radio System (SINCGARS), to maintain synchronous operation with the network for several days after loss of the GPS signal. The CSAC microsystem derives its timing stability by coupling a miniature laser, with associated electronic circuits, to an atomic transition in a reference gas. Recently we have demonstrated an innovative application of an alternative laser-atomic state interrogation scheme that allows more than an order-of-magnitude increase in the system's stability. This new scheme should enable an accuracy equivalent to the loss of less than a tenth of a second error in timing over 100 years of operation. We currently have plans to insert a CSAC into a SINCGARS radio to demonstrate that it can provide a time signal if GPS is not available.

Provide cyber operations dominance

It is increasingly clear that cyber warfare will be a major and growing part of future operations. In particular, cyber warfare offers the possibility that an adversary could inflict widespread technological surprise and damage. DARPA's mission is to prevent that sort of technological surprise. While much of our work in this area cannot be discussed in this forum, for several years DARPA has been making considerable progress to ensure that the United States is well prepared for this novel form of conflict.

Everyone understands the need for cyber security – what we at DARPA usually call "information assurance." We have been developing technologies to make DoD computers and networks not only secure, but also disruption-tolerant and, when attacked, self-reconstituting.

As the U.S. military adopts network-centric warfare, terrorists and other nation-states are likely to develop and employ malicious code to impede our ability to fight efficiently and effectively. The ever-growing sophistication of the malicious code threat has surpassed the ability of normal commercial markets to address this problem. For example, computer worms that have never been seen before ("zero-day worms") pose a specific threat to military networks because they have been shown to exploit thousands of computers using previously unknown network vulnerabilities in seconds.

The Dynamic Quarantine of Computer-Based Worm Attacks program has been developing dynamic quarantine defenses for U.S. military networks against large-scale malicious code attacks, such as computer-based worms, by creating an integrated system that automatically detects and responds to worm-based attacks against military networks, provides advanced warning to other DoD enterprise networks, studies and determines the worm's propagation and epidemiology, and immunizes the network automatically from these worms. The final system will quickly quarantine zero-day worms to limit the number of machines affected, as well as restore the infected machines to an uncontaminated state in minutes, rather than hours and days, which is today's state of the art.

Normally, large, homogeneous networks can be quite vulnerable to cyber attack: if all the network computers have identical operating systems and software, then a software vulnerability or fault in any one component or device can make the entire network vulnerable to catastrophic disruption. However, the vision of the Application Communities program is to turn network size and homogeneity into *advantages*. By sharing knowledge about attacks, configuration errors, and bugs – along with possible recovery strategies – a community of safely contained commercial off-the-shelf systems can use automated diagnosis, containment, and repair actions to prevent the spread of problems to other systems and restore normal functionality to those already affected.

In 2007, the Application Communities program demonstrated fully automated detection, diagnosis, and recovery of a 20-node community in response to a self-propagating zero-day exploit of an e-mail application vulnerability and a fully automated repair to an attack on Firefox that took advantage of a JavaScript bug. The attack was recognized and the response was initiated. Different repairs were attempted, and the third repair successfully resolved the problem, and Firefox was able to continue. The exploit was closed after only five attacks, ensuring that most community members could continue without any problems.

DARPA also has a role in the Comprehensive National Cyber Security Initiative, part of our FY 2009 budget request.

Part of our drive to keep the United States cyber-dominant is to ensure that our country has the highest-performance computers in the world. The High Productivity Computing Systems (HPCS) program is the Federal Government's flagship program in supercomputing. HPCS is pursuing the research, development and demonstration of economically viable, high productivity supercomputing systems for national security and industrial users. Phase III of the High Productivity Computing Systems (HPCS) program, encompassing design, development, and prototype demonstration, has been underway for a little more than a year. The program will culminate in a prototype demonstration at the end of 2010.

While the actual hardware will not be available to users until 2010, the vendors are making visible progress on software that contributes to achieving the program's goal of improving productivity. In 2007, several key pieces of software were released to our Mission Partners (i.e., the Department of Energy and the National Security Agency, who are helping to fund HPCS) for their assessment; some were also released to the entire high performance computing community.

<u>Remove the value of using biological weapons</u>

For over a decade, DARPA has pursued a variety of technologies to reduce the threat of biological weapons.

DARPA's vision is to develop technology so we can respond *quickly* and effectively to any biological warfare (BW) attack – whether it uses known or unknown pathogens – thereby blunting the effect of the attack and greatly diminishing its value. With this understanding of the strategic necessity for rapid response in mind, DARPA has pursued programs to rapidly identify pathogens, develop and evaluate therapies for treating the diseases they inflict, and then manufacture therapeutics in large quantities.

Figure 1 shows the various steps required to respond to an unidentified or novel BW attack. DARPA has been working to speed up these steps with the ultimate goal of producing three million doses of definitive therapy in less than 16 weeks after a pathogen has emerged.

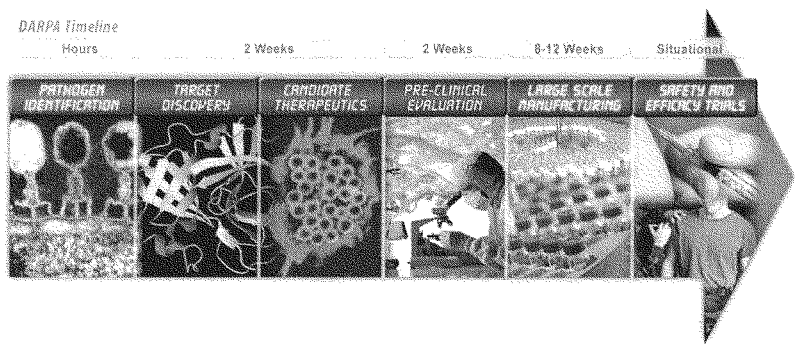

Figure 1: The steps to DARPA's goal of producing three million doses of definitive therapy in less than 16 weeks after a pathogen emerges.

Two major programs for rapidly identifying pathogens were TIGER and HISSS.

DARPA's Triangulation Identification for Genetic Evaluation of Risk (TIGER) program developed a "Gold Standard" universal sensor. TIGER is a strategic national asset that can detect any type of pathogen – even unknown and engineered ones – through an innovative method of measuring and weighing nucleic acid sequences. TIGER has been rigorously validated for biodefense applications, including surveillance for biological weapons agents in environmental samples and analysis of a broad range of biological samples for important human pathogens.

TIGER is completed and has been deployed to a number of places, including the U.S. Army Medical Research Institute of Infectious Diseases at Fort Detrick, Maryland, the National Institute for Allergies and Infectious Disease in Bethesda, MD, and the Centers for Disease Control. In 2006, two companies announced plans to manufacture and distribute a system that uses the DARPA TIGER technology, and the commercial unit is available for purchase.

In the arena of field sensors, DARPA's Handheld Isothermal Silver Standard Sensor (HISSS) program developed component technologies to enable a tactical-level handheld biological warfare agent sensor capable of laboratory-quality detection of the full spectrum of biological threats on the battlefield: bacteria, viruses, and toxins.

Once a pathogen has been detected, we need ways to quickly develop and evaluate a vaccine or other countermeasure. In this area, our Rapid Vaccine Assessment program is developing new methods to test vaccines and provide more precise, fast, and biologically relevant evaluation of human responses than conventional tissue culture systems or animal models. The Modular IMmune In-Vitro Construct (MIMIC) is the first-ever credible method for replacing animal vaccine studies with a safe, accurate approximation of the human immune system that does not require injecting people. MIMIC's potential to improve the safety of clinical trials and reduce the need for animal testing resulted in *R&D Magazine* honoring it with a *2007 R&D 100 Award* as one of 2007's 100 most technologically significant developments in the world.

MIMIC is currently transitioning to the DoD's primary medical countermeasure development office at Defense Threat Reduction Agency (DTRA) and several pharmaceutical companies. MIMIC's evaluation of both successful and failed vaccines will be compared with actual clinical data to demonstrate its ability to predict the immunogenic potential of vaccines prior to expensive and lengthy animal and clinical trials.

Once a vaccine, antibody, or immune enhancer has been identified by MIMIC and undergone pre-clinical evaluation, technology from our Accelerated Manufacturing of Pharmaceuticals (AMP) program could take over. AMP is developing strategies to rapidly and inexpensively manufacture millions of doses of life-saving drugs or vaccines in weeks, instead of the years required by today's manufacturing practices. AMP will do this by combining high-speed natural biological production systems, such as bacteria, fungus and plants, with powerful, flexible bioreactor and automated growth technologies to produce antibodies or vaccines quickly on an unprecedented scale.

AMP early results have already outperformed current vaccine production systems. For example, in November 2007, AMP's plant-based technology demonstrated the capability to produce over 800,000 doses of crude avian influenza vaccine within a month. A second platform demonstrated a high yield of 30,000 doses of raw viral vaccine per liter of culture. It is important to note that conventional influenza vaccine systems would have taken six- to nine-times longer to do the same using egg-based vaccine production. DARPA's next steps are to demonstrate that vaccines produced in these novel platforms are as pure and effective as those produced conventionally. Current plans call for AMP's best performing platforms to be transitioned to the Defense Threat Reduction Agency.

Increase survival from life-threatening wounds

As we send our men and women in uniform into harm's way, two of our solemnest duties are to do what we can to protect them, and to do everything we can to heal the injured.

With this obligation in mind, for the past several years DARPA has made great progress in technologies to protect our troops from harm, keep them at the peak of their performance, and care for them when injured.

As a long-term effort to reduce injuries, our PREventing Violent Explosive Neurological Trauma (PREVENT) program is a basic research program looking for the mechanisms of neurological injury – particularly brain injury – caused by blast.

We do not have a good enough understanding of the mechanisms behind the symptoms we are seeing. It used to be thought that peak overpressure was the primary mechanism for blast injury, but that does not appear to be the case for many of the neurological symptoms in today's wounded. PREVENT is an aggressive program to fully characterize the harmful components of blasts, including the brain effects of repeated small blasts that individually might not seem harmful. Once we better understand the physical mechanisms of neurological injury, we can design specific technologies to protect our warfighters against them.

Testing is underway to further examine the causes of injury. Initial tests with biological models have concluded that overpressure alone does not account for lasting neurological injury. Additionally, experiments have shown that even conventional explosives produce low-level electromagnetic pulses, which may further explain the complex presentation of brain injury resulting from blast.

Several DARPA programs have been aimed at maintaining the warfighter's peak physical and cognitive performance once deployed, despite extreme battlefield stresses such as heat and altitude, prolonged physical exertion, and sleep deprivation.

For example, the Peak Soldier Performance program has developed a completely new approach to maintaining normal body temperature in the face of extreme heat. The Rapid Thermal

Exchange Device is a special cooling glove into which one hand is inserted. A slight vacuum is applied to the palm, which contains special blood vessels that can act like radiators. Cold water circulates through the grip, and, as a result, large amounts of blood can be rapidly cooled, maintaining normal body temperature even in extreme heat or during exertion. A modified version of the cooling device will be undergoing field testing on Light Armored Vehicles this summer. Another version is being adapted to maintain body warmth during prolonged underwater diving operations.

DARPA researchers have identified a very safe, natural antioxidant – called Quercetin – and developed it into a new form that is now available to the military and the general public. Among Quercetin's many potential benefits is illness prevention. In a randomized, placebo-controlled study, Quercetin helped prevent viral illnesses, like colds and flu, after physical exertion. Following a strenuous three day exercise routine, 50 percent of the control group became ill with colds and flu, whereas only five percent of the Quercetin supplemented group did. This important immune protective effect will help keep our warfighters healthy during training and deployment. Quercetin has been commercialized as RealFX Q-Plus soft chews, which are now available through several commercial vendors, as well as to all military personnel at a 50 percent discount.

When our troops are injured or wounded, one of the most important things we can do for them is reduce their pain. Under our Soldier Self Care program, DARPA has been pursing a radically different way of treating acute, severe pain. The current best treatment is morphine, which reduces pain quite well. But because morphine acts on the central nervous system, it also impairs cognition and can dangerously depress body functions. Instead, DARPA is pursuing capabilities to protect cognition by blocking the pain receptors right at the injury site to prevent them from firing and sending a pain signal to the central nervous system. This will help a Soldier remain alert in dangerous situations.

This research is progressing well. We've shown the treatment is safe, and, at this point, even more effective than morphine -- but without morphine's side effects. The small company that developed the technology has been purchased by a large pharmaceutical firm, and there is a clinical development plan in place that is aggressively moving forward.

Hemorrhage continues to be the leading cause of death on the battlefield, accounting for about 50 percent of fatalities. To stop bleeding on the battlefield, DARPA's Deep Bleeder Acoustic Coagulation (DBAC) program has been working on a portable device to stop deep internal bleeding, which could be operated on the battlefield by non-medical personnel. The approach will utilize novel, high intensity focused ultrasound (HIFU) to detect, locate, and coagulate deep internal bleeders. The DBAC team includes test and standards development experts for HIFU devices at the FDA's Center for Devices and Radiological Health. Involving the U.S. Food and Drug Administration at the start of the program will help ensure that the transition from DARPA to the battlefield will occur as quickly as possible.

Complementing DBAC, the Surviving Blood Loss (SBL) program has been developing novel strategies to delay the onset of hemorrhagic shock due to blood loss, providing increased time for evacuation, triage, and initiation of supportive therapies. The program aims to extend the "golden hour" after severe trauma to six to ten hours, or more. SBL is working to understand the control mechanisms of energy production, metabolism, and oxygen utilization, and to identify and control the protective mechanisms that preserve cellular function despite critically depressed oxygen delivery. SBL has identified very promising compounds, including hydrogen sulfide and estrogen, that, in large animal tests, extend survival after lethal hemorrhage to more than three hours without requiring resuscitative fluids. Human safety trials for hydrogen sulfide, paid for by the company that created the technology, are proceeding on schedule.

There are no simple, automated respiratory support devices that are suitable for the combat medic. Breathing emergencies on the battlefield either go untreated or require the full attention of combat medics, leaving them unavailable to help other casualties. The SAVe: Portable Ventilator program developed an automated "Ambu bag" usable in theatre by the combat medic that is simple to operate, safe, rugged, and inexpensive. Since last year, the SAVe ventilator has been deployed with combat medics, and is saving lives today. Because of its compact size, ease of use, and cost, a modification of the SAVe is being developed for civilian emergencies, such as pandemics.

The Compact Volume Angio Computed Tomography (COMPACT-VAC) program has been developing a digital imaging system that is both markedly reduced in weight and volume, yet able to provide higher quality CAT scan images than any system currently available. Because of its size, the COMPACT-VAC will be suitable for deployment in vehicles such as the Stryker, enabling early diagnosis of injuries, including sources of bleeding.

Restore injured warfighters to the way they were

Building on our obligation to care for our troops when they are injured entails a longer-term obligation to do the best we can to rehabilitate them. DARPA's goal is to restore them, as best we can, to who they were before they answered the call to defend our Nation.

The goal of the Restorative Injury Repair (RIR) program is to fully restore the function of complex tissue, such as muscle, nerves, and skin, after traumatic injury on the battlefield. These injuries include both kinetic (i.e., penetrating) wounds as well as other destructive injuries such as chemical and thermal burns, musculoskeletal injuries, and blast overpressure. By developing a comprehensive understanding of wounds, RIR aims to replace nature's process of "wound coverage" through fibrosis and scarring, with true "wound healing" by regenerating fully differentiated, functional tissue at the wound site.

Improvements in body armor have increased survival, but also have led to more loss-of-limb injuries. Those losing a limb may be denied the chance to return to active duty if they wish. DARPA's flagship program in this area, Revolutionizing Prosthetics, holds the promise of ensuring they have that opportunity.

Current prosthetic leg technology is good and is improving. However, prosthetic arm technology is much more challenging, since it involves so many more joints and movements as well as the combined abilities to touch, sense, and manipulate fine objects.

Many of you saw this technology demonstrated here in the Rayburn Foyer back in October.

DARPA's goal is to revolutionize upper extremity prosthetics, specifically arms and hands. Today, individuals experience such prosthetics – to the extent they can use them at all – like a *tool*, not like a limb. We are developing a prosthetic arm that can be directly controlled by the brain and be used exactly as a natural limb, providing dexterity and sensation equivalent to a natural hand or arm. In two years, full clinical trials will begin on prosthetics that have functions almost identical to natural limbs in terms of motor control and dexterity, sensory feedback, weight, and environmental resilience. These devices will be directly controlled by neural signals. Our goal is to give our military upper limb amputees the chance to return to normal life and, possibly, active duty as quickly as possible.

We are making rapid progress: the program has already developed several prototype prosthetic arms that have entered clinical trials. These devices are far more advanced than any currently available, enabling many degrees of freedom for complex grasping and individual finger movements, while being rugged and resilient in all environments.

In January of 2007, the first generation prototype arm was fitted and attached to an amputee. Within hours and with minimal training, he was able to control the arm in all seven degrees of freedom, including a powered shoulder. Today, six patients, including two ex-Service members, have accumulated hundreds of hours experience controlling and using these arms. One patient, injured in Iraq, has even demonstrated the ability to manipulate individual fingers on a five fingered hand – something never done before.

In 2008, patients at Walter Reed and Brooke Army Medical Centers will begin training for this next generation DARPA-developed prosthetics. They will use both prototype limb systems and a simulation that will use signals generated by the user's brain or peripheral nerves to move and manipulate computer models of arms when new prototypes are manufactured in the lab. This "virtual integration environment" will allow users to tailor the responsiveness and control of their prosthetic limbs to their needs and daily demands, will allow patients an environment to train and practice with virtual limbs prior to manufacture of their final prosthetic, and will ensure that all patients have access to training with the latest limb systems.

Develop core technologies that maintain U.S. military superiority

I have just described seven broad areas where DARPA, over the last seven years, has made great progress in improving our systems and operational capabilities. The progress underpinning these accomplishments, in many cases, ultimately depends on the progress we continue to make in our core technology work, an area of DARPA's research that we emphasize largely independent of any particular set of circumstances. These core technologies are the investments in fundamentally new technologies, at the component level, that historically have been the technological feedstocks that lead to new systems and significant advances in U.S. military capabilities.

Quantum Science and Technology

Until recently, quantum effects in electronic devices did not have overriding significance. However, as device sizes shrink, quantum effects can influence device performance. DARPA is sponsoring research aimed at technology that exploits quantum effects to achieve revolutionary new capabilities.

DARPA's "Slow Light" program is exploiting the quantum properties of materials to control the speed of light and slow it to a tiny fraction of its normal speed. Such tunable control will allow storing and processing of optical information. This past year, the program demonstrated that slow light materials can slow, stop, and store two-dimensional images. The ability to slow, store and switch entire images before they are projected onto film or electronic detectors could lead to intriguing methods of capturing images, and further opens the door to novel approaches for ultra-high-speed image processing.

One example of a material that exploits quantum effects is superconductors, which conduct electricity with no energy loss due to electrical resistance.

High temperature superconducting materials cannot practically be modeled using quantum mechanics – even with today's fastest supercomputers. For example, a high performance computer running a quantum mechanical Monte Carlo code to calculate a phase diagram for one million atoms would require approximately four trillion years to complete the calculation. This computational intractability means that it is fundamentally infeasible to use computer models to systematically search for and identify new and manufacturable forms of these materials.

So, drawing inspiration from scale models and wind tunnels used to investigate aircraft designs, our Optical Lattice Emulator (OLE) program will construct a scaled artificial material – an emulator – whose mathematical and physical behavior is governed by the same underlying quantum mechanics as the superconductors of interest. This emulator will use approximately 10 billion ultra-cold atoms held in a lattice formed by laser beams. Controlling the states of the atoms in the optical lattice will help us understand properties directly related to the desired behaviors of real materials.

To illustrate the power of this emulation tool, OLE techniques would solve the million-atom phase diagram problem I previously referred to in a little over 10 hours.

The bottom line is that OLE will give us, for the first time, a practical tool to search for and identify the atomic compositions of special materials like room temperature superconductors that could be practically manufactured.

Bio-Info-Micro

For the past several years, DARPA has been exploiting and developing the synergies among biology, information technology, and micro- and nanotechnology. Advances in one area often benefit the other two, and DARPA has been active in information technology and microelectronics for many years. Bringing together the science and technology from these three areas produces new insights and new capabilities.

The Fundamental Laws of Biology (FunBio) program is working to discover the fundamental laws that govern the multiple, interconnected scales of biology – from molecule to cell to organism to population – that can be used to make accurate predictions about biological processes, just as physics-based theories enable predictions about the inanimate world. One part of the program has already delivered results with enormous potential benefits for both military personnel and the general public. Two FunBio team members have developed the first exact solution of a mathematical model that accurately captures the primary mechanisms underlying the rapid rise of resistance to antibiotics. These new mathematical approaches may be used to predict the next flu pandemic, or how a drug will affect a given individual. A new mathematical framework is also needed to discover information embedded in massive biological data sets, as well as to explain the significance of variability in physiological systems, which may provide a basis for personalized medicine.

Materials

DARPA continues to maintain a robust and evolving materials program. DARPA's approach is to push new materials opportunities and discoveries that might change how the military operates. In the past, DARPA's work in materials has led to such technology revolutions as high-temperature structural materials for aircraft and aircraft engines, and the building blocks for the world's microelectronics industry. The materials work DARPA is supporting today continues this heritage.

DARPA's current work in materials includes the following areas:

- *Structural Materials and Components*: low-cost and ultra-lightweight materials designed for structures and to accomplish multiple performance objectives in a single system;
- *Functional Materials*: advanced materials for non-structural applications such as electronics, photonics, magnetics, and sensors; and
- *Smart Materials and Structures*: materials that can sense and respond to their environment.

DARPA's Prognosis program has been developing the science and technology to revolutionize the maintenance of turbine engines. The idea is to do preventative maintenance when physics predicts it is needed, rather than just on a schedule. In 2007, the Air Force and DARPA agreed to transition Prognosis technology into the legacy fleet of F100 and F110 turbine engines that power the Air Force's F-15s and F-16s.

The Oklahoma City Air Logistics Center (OC-ALC) is one of three depot maintenance facilities responsible for repairing and maintaining aircraft and weapon systems. This includes managing and maintaining a $49 billion inventory of more than 30,000 engines. OC-ALC will receive a series of Engine Systems Prognosis tools to manage the life of the F100/F110 engine fleets. The ultimate goal is to maximize engine safety and readiness, while minimizing costs.

DARPA has successfully produced amorphous metal non-skid, highly wear-resistant surface coatings for potential use in the Waterborne Mission Zone (WMZ) of the Navy's Littoral Combat Ship (LCS). The WMZ is a large compartment located in the stern of LCS that is intermittently exposed to seawater and wear and tear from loading and unloading small craft. The LCS WMZ is a challenging environment, and is an ideal testbed for demonstrating the wear/corrosion resistance and damage tolerance of DARPA's coatings.

Researchers in our Naval Advanced Amorphous Coatings (NAAC) program have devised a thermal spray technique that produces textured coatings with a high coefficient of friction and wear, impact, and corrosion resistance that is superior to any other corrosion-resistant, non-skid material. Today's corrosion protection and non-skid coatings are usually replaced every 12-24 months, interfering with ship readiness and significantly increasing maintenance expenses. If successful, NAAC's goal is to require coating replacement only during pre-scheduled, major refits of the ship.

The DARPA Titanium Initiative to produce aerospace-grade titanium at $3.50 per pound is continuing with scale-up efforts to increase capability to 500 pounds per day. This program developed a continuous chemical reduction process that extracts both pure titanium metal and titanium alloy powders from inexpensive feedstock, and a meltless production process for fabricating parts inexpensively. These were selected by *R&D Magazine* to receive a *2007 R&D 100 Award.*

Protecting our warfighters from asymmetric attacks is an ever-present challenge. Improvised explosive devices (IEDs) remain a significant threat to our forces in Iraq and Afghanistan. Our Hardwire program has developed a novel armor concept primarily to protect vehicles. Hardwire's unique composition and topology has demonstrated outstanding protection against armor piercing rounds, fragments, and IED fragmentation. Hardwire's armor weight is much lower than steel armor, meaning that we can achieve protection equivalent to conventional armor at much lower weight, or greater protection at the same weight. More recently, we have been looking at Hardwire's effectiveness in protecting against Explosively Formed Projectiles (EFPs).

Power and Energy

To Napoleon's dictum that an Army moves on its stomach, today's warfighting forces could add, "...and on energy."

Developing portable, efficient, and compact power supplies has important ramifications for increasing our military's reach, while at the same time decreasing material logistic requirements.

One of our flagship programs here is the Very High Efficiency Solar Cell program, aimed at developing photovoltaic modules with efficiencies exceeding 50 percent. The program has a novel design architecture that integrates previously incompatible materials technologies to maximize performance across the solar spectrum. The optical system and key device elements have already achieved record efficiencies – a huge step towards our goal. Early evaluation of the integration of this technology with military battery packs has been very positive. The ultimate objective of an affordable, mass-produced, 50 percent efficient solar module appears well within reach. This will dramatically reduce the battery load on soldiers and on the logistics pipeline. In addition, within a few years of the commercialization of these technologies, the design and manufacturing technology breakthroughs coming from this program will be driving high efficiency module costs to $1 per watt and below.

To help reduce the military's reliance on petroleum-based fuels to power their aircraft, ground vehicles, and ships, DARPA's BioFuels program is working to develop an affordable surrogate for military jet fuel (JP8) derived from oil-rich crops such as rapeseed, other plants, algae, fungi, and bacteria. Initial efforts in the BioFuels program have already delivered BioFuel samples that have passed the key JP8 initial qualification tests – these are BioFuels whose performance is indistinguishable from petroleum-based JP8. The BioFuels program is expanding the development of processes for cellulosic and algal feedstocks with the ultimate objective of providing for an affordable, significant, and diverse supply of military jet fuel.

Power sources limit the size and weight of many electronics and sensing technologies used by our military today. DARPA's Micro Power Sources (MPS) program is working to develop extremely small batteries to remove the "volume bottleneck" in the design of these systems. To-date, DARPA-funded researchers have used a laser micromachining process and enhanced electrochemistry to produce a microbattery that has the energy density of a standard lithium-ion battery, with the goal of achieving 1/100th of its size. The ultimate goal of the MPS program is to produce a battery with a volume less than one cubic millimeter. This is 1/1000th the size of batteries in, for example, today's cell phones – and with comparable energy density (350 watt-hour/liter). Battery size reductions of this magnitude will enable an entirely new generation of ultra-small sensors and actuators for a wide range of military applications, including ultra-small autonomous vehicles.

DARPA's Robust Portable Power program is continuing to develop advanced, ruggedized fuel cells for several military applications. Soldier power applications in the 20-50 watt range include laser designators, mine sweepers, chemical detectors, heavy thermal weapons sights, radios, and toughbooks. Fuel cell applications in the 150 watt range include providing power for robots and unmanned air vehicles.

Microsystems

DARPA is shrinking ever-more-complex systems into chip-scale packages, integrating microelectronics, photonics, and microelectromechanical systems (MEMS) into "systems-on-a-chip" that have new capabilities. It is at the intersection of these three core hardware technologies of the information age that some of the greatest challenges and opportunities for the

DoD arise. The model for this integration is the spectacular reduction in transistor circuit size under Moore's Law. Electronics that once occupied entire racks now fit onto a single chip containing millions of transistors. Being smaller helps these devices to operate at radio frequencies.

Recently, the 3-Dimensional-Integrated Circuits (3D IC) program has demonstrated a 3-dimensional via[2] technology, enabling a significant performance boost for silicon radio frequency (RF) devices. The initial application of this technology is for silicon-germanium bipolar complementary metal oxide semiconductor wireless communication chips for power amplifiers used in wireless systems. Future enhancements to this process will provide powerful 3-D integration technology for enhancing state of the art silicon RF technology.

In addition, programs exploiting the very high-speed properties of compound semiconductors demonstrated power efficient and highly linear low-noise RF amplifiers, which are crucial components for next generation radar, communications, and electronic warfare systems. The Feedback Linearized Amplifier for Radio Frequency Electronics program recently demonstrated the world's first microwave operational amplifier with the highest linearity figure of merit ever reported for any low noise amplifier. At two gigahertz, a record linearity figure of merit was achieved – roughly four times higher than that of any low-noise RF amplifier in use today.

Another important application of compound semiconductor materials is imaging and communication in the terahertz region. The Sub-millimeter Wave Imaging Focal-plane Technology program is pushing the high-frequency performance limits of radio frequency microelectronics. Over the past year, the program fabricated the first transistor that can supply greater than unity power gain at a frequency of at least 1.0 terahertz.

The Scalable Millimeter Wave Architectures for Reconfigurable Transceivers program has demonstrated the most complex millimeter-wave radio frequency integrated circuit ever developed: a highly integrated, Q-band (35-55 GHz) 16-channel receive-side beamformer-on-a-chip. This chip, which contains about 1200 radio frequency transistors, integrates all the required beamforming elements for an electronically steered phased array antenna onto a single

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[2] A via is a small opening in an insulating oxide layer that provide electrical interconnections between layers of integrated circuits

silicon die with a 3.2 x 2.6 square millimeter area. This compact beamforming chip will enable a breakthrough in size, weight, performance and cost in next-generation phased arrays for millimeter-wave military sensor and communication systems.

The 3-Dimensional Micro Electromagnetic Radio Frequency Systems (3-D MERFS) program seeks to revolutionize the performance, cost, and form factor of military communication and radar systems by, for the first time, creating a low-cost high-performance printed-circuit board technology for RF and millimeter wave systems. To replace current micro-strip or stripline waveguide technologies, the 3-D MERFS program has developed the first new waveguide structure in more than a generation – a three-dimensional, lithographically printed rectangular coaxial waveguide. This waveguide out-performs even expensive structures like microstrip on gallium arsenide, with seven times less loss, and 10,000 times better isolation. More importantly, the technology allows fabrication of complex systems with minimal touch labor, decreasing cost and increasing system reliability.

Information Technology

Information technology, which supports a broad set of opportunities to improve our military capabilities, is a core technology that DARPA has supported for decades.

A key area in information technology is embedded systems: computing systems that are built into a platform or system, that help direct or manage it and make it more intelligent and capable in performing such operations as flight control, targeting, sensor performance, onboard data analysis and management, and electronic countermeasures. Embedded computing is critical across a broad range of military applications, such as handheld devices used in the field, intelligent weapon systems, autonomous platforms, and airborne information and command centers.

Current DoD embedded computing systems are typically point-solutions, tailored to a specific, static, and inflexible set of mission requirements. This approach leads to one-of-a-kind systems that are inflexible in purpose, costly to develop, and unable or extremely expensive to adapt to changing requirements.

DARPA has recently been pursuing technologies to overcome these limitations in the Polymorphous Computing Architectures (PCA) program. PCA has created a class of innovative, flexible, high performance single-chip processing architectures that can be optimized to efficiently implement a broad set of DoD applications and adapt to changing missions, sensor configurations, and operational constraints during a mission or over the life of a platform. The architectures are based on replacing many processing types/configurations with a single reconfigurable processing architecture. Rather than requirements having to adapt to existing processors, PCA architectures can be optimized to the application.

PCA is only one part of DARPA's pursuit of advanced and enabling processing architectures. Earlier I discussed our HPCS program, which we hope will come to fruition in the next few years. But DARPA is already looking beyond HPCS, and is laying the foundation for the next set of investments to dramatically improve processing capabilities.

Our ExaScale program is pursuing concepts that include self-aware processing to enable systems that know their state and react to self-optimize their performance; integrated processing core developments to provide optimized performance and advance processing capabilities at multiple levels -- embedded, departmental, and high performance computing centers; architectural concepts to revolutionize how we think of memory versus logic; rapid turn-around, high-performance customizable processing approaches; compiler environments to enable the effective and efficient use of complex processing systems for DoD applications; and techniques to recover, maintain, and redeploy the considerable investment in critical existing application codes.

As I mentioned last year, DARPA also has some programs to generate exciting new ideas in computer science and attract students to the subject.

Our Computer Science Study Group (CSSG) program educates a select group of extremely talented early-career academic computer scientists on DoD's needs, and then asks them to use the knowledge they've gained to propose ideas for basic research relevant to DoD. The program plans a multi-phase cycle for each class of about 12 participants. In the first phase, the participants obtain a Secret clearance and are familiarized with DoD and its challenges through group visits to DoD's labs, bases, defense contractors, and operational settings. The visits occur during four week-long trips during the first year. In the second phase, the participants' ideas are competed, and the best proposals may be awarded up to $500,000 to conduct basic research of interest to DoD. In the third phase, the participants may be awarded an additional $250,000 for their research, provided they find matching funds from another source.

We have now selected three classes for CSSG, with the first two classes delving further into their research projects. As an example, one of the research projects will look at novel ways to network wireless imaging systems and other wireless sensors, emphasizing change detection. This has obvious counterterrorism applications. Another example is a novel way of using algorithms and sampling to detect similarities in data and exploit those similarities to minimize existing bottlenecks and inefficiencies in network data transfer. A third project initiated development of a secure, coherent software methodology for information-sharing for both cross-domain and intra-domain communication applications.

Our Computer Science Futures program is aimed at attracting and cultivating talent for computer science, in this case linking up world-class computer science researchers with interested high school students. Here we ask a panel of young computer science professors to propose "Grand Challenges" for computer science – problems that are important, hard, and exciting to tackle. The professors then brief their ideas to high school students, and the students are asked which of the challenges are exciting enough to draw them to study computer science.

In the first year, the students ranked three challenges as most interesting, led by the Programmable Matter Challenge, which seeks to use programming to direct mobile units to form dynamic three-dimensional objects. The students were also interested in merging computer science with other fields and using computer science to enhance safety. The second year yielded six challenges that were again presented to high school students. One of the ideas that the students liked this time around was the Computational Biology Challenge. The goal, which is of significant relevance to DoD, is to develop computational models of embryological development that can be used to understand why life adapts well to certain environmental changes. The models are relevant to understanding why some types of computer networks are vulnerable to attacks and failures, while others are resistant.

Mathematics

Our current mathematical themes include topological and geometric methods, inverse methods, multiresolution analysis, representations, and computation that are applied to design and control complex systems, extract knowledge from data, forecast and assess risk, develop algorithms, and perform efficient computations. These techniques underlie key Defense applications such as signal and image processing, and aid in understanding biology, materials, sensing, and design of complex systems.

For example, DARPA's Topological Data Analysis (TDA) program uses novel mathematical concepts and techniques to develop algorithms that identify and extract hidden geometric properties of massive data sets. These algorithms will result in new, ultrafast, user-friendly software tools.

Recent program results include key insights in such diverse fields as images, material science, cancer biology, virus evolution and medical diagnostics. Distinguishing high-dimensional patterns in the statistics of natural images is leading to the development of a novel, non-linear, compression scheme that will revolutionize the way that images are analyzed. Similarly, TDA methods will transform the way that doctors triage patients, through construction of non-linear, non-invasive medical statistics to assess patients in intensive and critical care situations.

Another DARPA mathematics program, Sensor Topology for Minimal Planning (SToMP), leverages high-dimensional mathematical insights from topology and geometry to create new DoD capabilities in network and sensing problems. The program creates mathematical innovations to extract an overall picture from local information in distributed and coordinated sensing platforms. Recent SToMP results on sensor coverage and tracking issues are revolutionizing how networked sensors and autonomous sensor agents are analyzed, distributed, and controlled.

Manufacturing Science and Technology

The DoD requires a continuous supply of critical, defense-specific materiel and systems. To ensure reliable, robust, and cost-effective access to these items, manufacturing technologies that can meet DoD's needs must be available within our industrial base.

DARPA's Disruptive Manufacturing Technologies (DMT) program is developing manufacturing technologies and processes to provide significant and pervasive cost savings for multiple platforms or systems, and/or decreases in manufacturing cycle time for components for existing and future military procurements.

In this program, we are piloting new manufacturing process initiatives in microwave electronics, adaptive software development, and advanced materials. We are focusing on producing microwave amplifiers for electronic and information warfare, radar, and communication systems; designing and producing adaptive software-intensive systems; and revolutionary new, faster, and lower-cost methods for producing polymer matrix composites for aerospace components, superalloy high-strength blades that power aircraft turbine engines, and boron carbide inserts for body armor.

For example, DMT will leverage 3-D MERFS technology (described earlier in the *Microsystems* section) to increase power handling capability and ease the integration of 3-D MERFS structures with other components. The goal is to replace traveling wave tube amplifier (TWTA) systems used by aircraft towed-array-decoy systems with solid-state devices that cost ten times less. If successful, the program will result in more than $150M savings for planned TWTA procurements alone.

More importantly, however, the intimate integration enabled by the DMT program promises to break through the cost barrier that has kept many radar and communication systems so expensive. Many such systems are limited by the cost of monolithic microwave integrated circuit (MMIC) components. These components are fabricated on novel and expensive substrates, typically at very low yield. The DMT program will enable the majority of components to be removed from the MMICs and placed in higher performing 3-D MERFS substrates. This will decrease the amount of expensive substrates required by several orders of magnitude, as well as dramatically increase yields, resulting in higher performance systems at significantly lower cost.

Lasers

Lasers have multiple military uses, from sensing to communication to electronic warfare to target designation. Since the technology was first demonstrated, the DoD has maintained a steady interest in High-Energy Laser Systems (HELS) for a wide range of speed-of-light weapon applications. Starting in the early 1960s, DARPA has been involved in lasers and laser technology development for the DoD, and continues its work today in this crucial area.

The High Energy Liquid Laser Area Defense System (HELLADS) program offers dramatically reduced size and weight so that the system can be mounted on a variety of platforms for self-protection. HELLADS is developing a high-energy laser weapon system (approximately 150 kilowatts) with an order-of-magnitude reduction in weight compared to existing laser systems. With a weight goal of less than five kilograms per kilowatt, HELLADS allows for new and innovative capabilities, such as use on tactical aircraft systems for effective self-defense against even the most advanced surface-to-air missiles.

Last year, the program demonstrated 15 kilowatts of multimode laser output power. The current focus is on completing the development of a unit cell laser module that will scale directly to 150 kilowatts and on the weaponization of a solid-state laser. HELLADS has already developed a laser that overcomes the fundamental limitations of solid-state lasers. The program now offers the opportunity to greatly accelerate the fielding of a small-size, low-weight tactical laser weapon that will transform operations and provide a tremendous advantage to U.S. forces.

DARPA has also been working to improve the performance of components used in high-energy laser systems. Over the past year, the Super High Efficiency Diode Sources (SHEDS) program has succeeded in improving the efficiency of diode lasers intended for use in HELS pumping sources by nearly a factor of 1.5, from 50 percent to 72 percent, with a corresponding 50 percent decrease in the waste heat. In addition, the efficiency of the vertical cavity surface emitting diode laser array has increased from 18 percent to the current record of 51 percent, and the power intensity is double that of standard edge-emitters. These advances should enable dramatic reductions in the size and weight of HELS and the development of portable HELS platforms.

Military applications of high-power lasers also require precise steering of tightly focused optical beams. The Adaptive Photonic Phased Locked Elements (APPLE) program is developing a revolutionary optical phased array technology that coherently combines an array of fiber lasers with all-electronic beam steering. For aircraft-mounted HELS, this approach should simultaneously reduce atmospheric effects and scale to weapons-grade power levels. For high-power applications, 100 sub-apertures, each driven with kilowatt-class fiber lasers, can all be directed to the same small spot on a distant target.

In closing, DARPA's progress over the past seven years in the eight areas has been impressive, and would not have been possible without the tremendous support we've received from Congress. As DARPA celebrates its 50th anniversary this year, I can report that, with Congress' continued support, DARPA is positioned to provide even more important capabilities that will benefit our Nation and Armed Forces.

DARPA was created out of the shock of Sputnik, and it is clear that the overall strategic situation of the United States is quite different than it was 50 years ago. Nevertheless, the need for DARPA's mission – to prevent the technological surprise of the United States and create it for our adversaries by keeping our military on the technological cutting edge – remains.

QUESTIONS SUBMITTED BY MEMBERS POST HEARING

MARCH 13, 2008

QUESTIONS SUBMITTED BY MR. SMITH

Mr. SMITH. In complex irregular warfare operations, technological superiority (big platforms) may not be an effective force multiplier. Instead, "soft" skills, such as languages, cultural awareness, information operations/psychological operations, and civil affairs may be required. a. How can technology help the U.S. military rapidly acquire the "soft" skills it needs to be effective in irregular warfare operations? b. How does technological superiority fit within today's threat environment?

Admiral LANDY. a. The use of technology to develop "soft" skills, including language skills, cultural awareness, effective information operations/psychological operations and civil affairs, is the focus of the Office of Naval Research's programmatic investments in social, cultural and behavioral sciences. The objectives of these programs are to

- Understand and forecast human behavior in ethnically diverse societies as viewed from perspectives that scale from the individual to organizational and societal levels of understanding
- Develop empirically informed and validated computational models of the socio-cultural determinants of the opinions, values, attitudes and actions of individuals and groups in societies of current and anticipated operational interest
- Create the knowledge base and virtual and immersive training science that will provide the warfighter with the language and cultural skills necessary to fight effectively in the complex irregular warfare environment
- Develop training technologies that will provide warfighters the ability to understand, exploit, and forecast the effects of information and psychological operations.

Technologies developed in the pursuit of these objectives can be applied by Naval analysts, planners, trainers, combatants, and by the intelligence community for a variety of purposes, including:

- Supporting the development of strategies to influence the opinions and attitudes of individuals and groups toward terrorism as a political solution and toward the United States and its institutions and interests
- Forecasting terrorist activity and the likely reactions of terrorist organizations to possible US interventions
- Understanding and more effectively combating the radicalization process
- Developing more systematic approaches for reasoning about the likely behaviors of asymmetric agents and their networks
- Creating training curricula for military decision makers and members of the intelligence community in counter-terrorism, irregular warfare, and stability, security, transition and reconstruction (SSTR) operations.

The Office of Naval Research is currently supporting technology development programs to achieve these capabilities. Three examples are the Marine Corps Immersive Infantry Trainer at Camp Pendleton, California, the Integrated System for Language Education and Training (ISLET), and the NonKin (non-kinetic) Village program. The Immersive Infantry Trainer provides an immersive environment for fire teams and squads to train in a reconfigurable urban setting that combines live and virtual training. ISLET will provide highly-motivating education and training in foreign language and culture on an immersive web-based gaming platform. The NonKin Village program is developing a serious game that teaches COIN (counterinsurgency) theory for operations within culture-specific civilian populations.

b. Technological superiority in future Naval concepts will not necessarily equate to big platforms. As we strive to create and sustain a Navy and Marine Corps that can be successful in both the peer competitor and asymmetric warfare environments, technological superiority requires both traditional large weapons systems and emerging areas of enhanced operations, effective use of cyberspace, persistent maritime domain awareness, etc.

Technological superiority is still critical, but we must expand our understanding of what that implies and ensure that technology development for use in irregular warfare is done in lock step with developing tactics, techniques, and procedures as well as training to wield that superiority effectively.

Mr. SMITH. The DOD S&T Program is chartered, in part, to ensure the Department avoids technological surprise. Yet some may argue that DOD has been technologically surprised by IEDs, EFPs, and cyberwarfare. What efforts does your organization undertake to avoid technological surprise? How are these different than they were five years ago?

Admiral LANDY. At the Office of Naval Research (ONR), we believe that planning in the face of uncertainty requires an investment in building and strengthening the breadth of science and technology (S&T) capacity to allow Naval S&T (and thereby Naval Forces) the ability to anticipate and respond to unforeseen and new threats. The "breadth" of the Discovery and Invention (D&I) portfolio is manifested through the diverse set of Research Areas of investment. It is these D&I investments in Naval relevant fields that build S&T capacity. The strength of this approach is tested when a new need arises, and the portfolio has a suite of ideas and performers that can in a short period develop a technology for the new threat. One key example of this is the Counter IED jammer work in 2006 that resulted from broad "basic and applied" research investments in Electronic Warfare. When the need arose, ONR was able to tap into research at The Naval Research Laboratory to very quickly develop, test, and field an electronic warfare jammer for OIF.

In addition to a robust D&I portfolio, avoiding technological surprise requires an awareness of the rapid pace and direction of S&T worldwide. ONR initiated an effort in 2006 to integrate information and assessments of a range of communities along with the international S&T perspective and our own S&T programs to ensure we capitalize on the full range of opportunities as well as understand the emerging threats and capabilities outside of the United States. These communities come together on a quarterly basis to discuss specific S&T topics of naval relevance and ensure that our S&T investment is focused and paced accordingly.

Finally, the mix of Research Areas within the D&I portfolio is adjusted as new Naval needs, emerging discoveries, make "new ideas" more feasible. Our list of emerging areas for investment is adjusted to reflect the shifting set of adversaries, threats and global technology trends.

This philosophy of "breadth" in investments coupled with the "reach" to global communities allows Naval S&T the capacity to both anticipate and respond to technology surprise.

Mr. SMITH. The DOD S&T Program investment strategy should balance the development of (a) technological countermeasures to perceived future threats, (b) technologies to create options for U.S. forces, and (c) technologies to shape our enemies' options. Could you provide some examples of investments you are making in each category and could you please discuss your vision for the appropriate distribution of investments for each category?

Admiral LANDY. The three stated components of the DOD S&T Program investment strategy are certainly fundamental to a sound S&T portfolio but there are additional factors that influence program priorities and decisions:

- Technologies to address high priority, short term needs that emerge from our engaged forces worldwide
- Investments that provide technology options for Navy and Marine Corps capabilities
- Investments to guard against technological surprise
- Technologies for affordability, maintainability, and reliability
- Investments to reduce acquisition program risk and cost
- Investments to ensure the future health of the scientist and engineer workforce in S&T areas critical to DOD

Since the three components from the question are not mutually exclusive, and the additional factors above must also be taken into consideration, it would be difficult to assign a numerical percentage as a strategic goal for the DON. In fact, most DON S&T programs would readily support two and some all three of the components. Nonetheless, the DON regards each to be of equal merit for developing Naval S&T program priorities and to ensure future Naval warfighting dominance against envisioned and potential threats.

(a) **Technological countermeasures to perceived future threats:**

Cyberspace/Cyberwarfare: DOD is faced with increasing level and sophistication of hostile cyber activities and must be able to fight through successful attacks on our data, systems, and networks. DON programs in information assurance and anti-tamper are geared to ensure high assurance software-enabled systems that are secure, affordable, sustainable, and interoperable.

Electronic Warfare: The S&T objectives in EW are to explore and develop new and innovative approaches, concepts and technology to address near and far term emerging threats to Naval platforms and personnel. More specifically, to ensure naval platforms can rapidly detect, identify, and classify electronic emissions, to develop effective countermeasures to advanced infrared and focal plane array technology, to develop effective countermeasures to advanced radar waveforms and modulation techniques, and to develop reduced size/weight/power/cost of EW components.

(b) **Technologies to create options for U.S. forces**

Distributed sensor networks: Persistent, distributed, networked sensors in all domains will ensure the broadest range of warfighting options available to the fleet and force commander. Unambiguous and comprehensive assessment of the battlespace will ensure unhindered access to denied areas while putting enemy forces at risk.

Lightening the load for the Marine: Current individual combat Marine loads vary from 97 to 135 pounds versus a recommended maximum of 50 pounds. Considerable information based on current combat operations indicates heavier loads severely reduce Marine effectiveness on long patrols, during close-in urban combat, and other adverse situations. S&T initiatives will treat the Marine as a system to develop improvements in combat load, ergonomics, power generation, nutrition and fatigue management to improve Marine performance and enable tailorable equipment packages.

(c) **Technologies to shape our enemies' options**

Electromagnetic (EM) Rail Gun: The EM Rail Gun uses electromagnetic energy instead of chemical propellants to propel a projectile farther and faster than any preceding gun. The rail gun offers the potential for a transformational solution for volume fires and time-critical strike.

Speed of Light Weapons: The threats to Naval forces in the open ocean and littoral regions include high-g cruise missiles, aircraft, high-speed patrol craft, jetskis, and floating mines. Current defensive systems require kinetic kill projectiles (bullets and missiles) all of which involve a finite time of flight to destroy the threat, are subject to countermeasures, and require a large storage magazine. The Navy Free Electron Laser (FEL) will allow near instantaneous engagement and destruction of the full range of current and projected surface and air threats while providing an unlimited magazine.

Mr. SMITH. The U.S. Special Operations Command FY09 S&T request is around $65 million this year which includes $11 million in a new area designated for SOF Information and Broadcast Systems advanced Technology. Can you briefly describe how the Special Operations S&T requirements fit into the overall DOD S&T planning process? Will we continue to see the SOF S&T budget grow to meet their unique mission challenges?

Admiral LANDY. The Office of Naval Research (ONR) is continually discussing and leveraging Naval Science and Technology (S&T) efforts with the U.S. Special Operations Command. While ONR coordinates on these S&T investments, it has no input into how they devise and plan their budget. ONR defers to the U.S. Special Operations Command in order to provide a response to this question.

Mr. SMITH. Within the next year or so, several defense bases will begin closing and various activities will begin re-alignment including research and development activities within the defense laboratories. One of the greatest impacts of BRAC is loss of talented workforce. Certain key folks may not wish to uproot their families to move to another state. How will the affects of BRAC (workforce and others issues) impact your ability to provide the best capabilities for our warfighters? What mechanism have you put in place to minimize the potential impact?

Admiral LANDY. The major 2005 Defense Base Closure and Realignment (BRAC) Commission recommendation impacting research and development activities and Navy laboratories was the creation of a Naval Integrated Weapons and Armaments (W&A) Research, Development & Acquisition, and Test & Evaluation (RDAT&E) Center, and realignment of W&A, RDAT&E functions, with some exceptions, to NAWC China Lake. The most significant impacts of this recommendation will be felt at: Naval Surface Warfare Center (NSWC) Crane, IN; NSWC Indian Head, MD; Naval Air Station Patuxent River, MD; Naval Base Ventura County (NBVC) Point Mugu, CA; Naval Weapons Station (NWS) Seal Beach, CA and NSWC Dahlgren, VA. This recommendation represents the bulk of the BRAC technical consolidations impacting Navy activities.

This recommendation enables technical synergy, and positions the Department of the Navy to exploit center-of-mass scientific, technical and acquisition expertise with weapons and armament Research, Development & Acquisition that resided at ten locations into the one Integrated RDAT&E site. The Office of Naval Research (ONR) believes these BRAC consolidations will improve our ability to deliver capability to the warfighters. Although there may be some loss of senior expertise, the center-of-mass will allow for collaboration and thus have a multiplier effect. ONR anticipates that any loss will be addressed through the use of planned successions and targeted recruitments. The use of retention bonuses and recruiting bonuses and other hiring flexibilities, approved by Congress and implemented at the technical laboratories will be fully utilized to ensure the required expertise is available.

Mr. SMITH. The mission of the Military Critical Technologies Program (part of the International Technology Security (ITS) office in DDR&E) is, in part, to identify technologies which contribute to, or have a potential to threaten, U.S. national security and to evaluate trends which might affect the availability of such technology. In addition, each of the services has Industrial Base Planning funds, to conduct studies of the health of the industrial base and to determine whether or not the industrial base continues to be able to provide military critical technologies. In the Office of the Secretary of Defense, the Industrial Policy office also conducts studies to ensure technological capabilities are sustained in the industrial base. Finally, the Manufacturing Technology program also seeks to improve the technological capabilities of the DOD industrial base. a. How are your Industrial Base Planning activities coordinated with those of the DUSD (Industrial Policy)? b. How are your Industrial Base Planning activities coordinated with your Manufacturing Technology programs?

Admiral LANDY. a. The Office of Naval Research does not have responsibility for Industrial Base Planning. ASN (RDA) is DUSD (Industrial Policy's) primary interface for matters of naval industrial policy.

b. For the Navy Manufacturing Technology (ManTech) Program, strategic planning is driven by the Navy's current acquisition plan and priorities. Currently, the ManTech Program is focused on shipbuilding affordability for four primary platforms the VIRGINIA Class Submarine, CVN 21, DDG 1000, and the Littoral Combat Ship (LCS).

The ManTech Program coordinates on an ad-hoc basis with Deputy Under Secretary of Defense (Industrial Policy) when it makes sense. As an example, Navy ManTech jointly funded an industrial base study in 2007 which focused on the mid-tier shipyards, analyzing shipbuilding technology and capabilities in nine mid-tier U.S. shipyards and five international shipyards. The principal output is a list of proposed actions for individual shipyards, industry as a whole, and the Department of Defense that will improve the performance of the U.S. shipbuilding enterprise.

Mr. SMITH. A recent DSB study on the Manufacturing Technology program recommended creating a Basic Research account for ManTech. The Navy already has a Manufacturing Science program. Do you agree with the DSB's recommendation? How would such a Basic Research effort within the ManTech program support the program's mission?

Admiral LANDY. The Defense Science Board (DSB) study on Manufacturing Technology discusses the value of basic research in manufacturing. The report cites the return on even a modest investment, notes the small scale of the current investment—much less than 1% of all Department of Defense basic research funds, and mentions that several American universities have the capacity to conduct world-class manufacturing research.

We agree that a basic research program in manufacturing is valuable and should invest in disruptive science and technology, focusing on new scientific understanding of the control of physical processes for production. The DSB cited nanotechnology as an example disruptive technology. Nanotechnology creates new production capabilities and in some cases new alternatives that provide more potential than existing capabilities. ONR has a large investment in nanotechnology at the Naval Research Laboratory. This effort is focused on developing the ability to affordably fabricate structures at the nanometer scale that will enable new approaches and processes for manufacturing novel, more reliable, lower cost, higher performance and more flexible electronic, magnetic, optical, and mechanical devices.

The Navy's current manufacturing science program is focused on exploring potential disruptive technologies known as direct digital manufacturing (DDM).

The transformative aspects of DDM systems include:

- on-demand production and repair of parts and components at point-of-use,
- mass-customization,

- affordable small job lots,
- short production cycle at low-cost, and
- real-time quality control.

The Navy manufacturing science program supports the naval science and technology strategy focus area for Affordability, Maintainability, and Reliability.

Mr. SMITH. From an S&T perspective, which do you perceive as the greater threat to national security and to our military forces—endemic infectious diseases, such as influenza or HIV, or weaponized bio-terror agent, such as Plague? That is, which represents the greater threat and the greater S&T challenge?

Admiral LANDY. Endemic infectious diseases are more common, are as deadly as weaponized bio-terror agents, and may present a greater challenge to S&T because of their ability to constantly change and evade the vaccines and drugs developed to counter them. Influenza and malaria are just two examples. There are also numerous endemic agents, such as dengue and most bacteria and viruses causing gastroenteritis, that present a formidable S&T challenge, and for which we have not yet developed effective countermeasures even after many years of aggressive research and development. However, as the post 9/11 anthrax letter mailings have demonstrated, the threat of a deliberate release of bio-terror agents is real, and our national security requires a robust S&T effort to ensure the availability of strategies to mitigate the threat. Complicating bio-terror agent defense is the fact that they can be deliberately engineered to evade existing countermeasures. Thus, although the threat of infection with a weaponized bio-terror agent such as anthrax may be lower than with an endemic infectious disease agent, focusing exclusively on one of these agents leaves us vulnerable to the other.

Mr. SMITH. Current DOD and service laboratory and research, development, and engineering center facilities are located in a large number of locations. Many of these facilities are aging and either poorly equipped or the equipment is out of date. What is your assessment of the DOD science and technology infrastructure? What measures are needed and what measures are being taken to maintain the DOD science and technology infrastructure required to support the discovery and development of advanced technologies for the Department of Defense?

Admiral LANDY. In 2008, the Navy Research Laboratory (NRL) completed a Corporate Facilities Investment Plan that provides strategic direction for the expenditure of laboratory overhead and MILCON funds to renovate spaces to meet its evolving R&D needs in the 10-15 year time frame. Primarily through its investment of overhead funds, NRL has been able to maintain its status as a world-class laboratory. Unfortunately, that solution is not sustainable in the long term.

Working Capital Fund laboratories manage their own Capital Investment Program (CIP) for infrastructure revitalization. The CIP allows the use of "internal" (vice specific appropriated) funds to revitalize infrastructure.

Mr. SMITH. In previous years, Congress has enacted a number of pilot demonstration programs to provide more flexibility in the hiring practices, management, and conduct of the science and technology program in selected DOD agencies and the military department laboratories and research, development, and engineering centers. Have these authorities been useful? What are some of the challenges with implementing these authorities?

Admiral LANDY. The laboratory personnel demonstration projects have demonstrably improved the ability of the laboratories to meet their mission—and at the same time pioneer new concepts of personnel management for the rest of the Department. Using the authorities granted by Congress in the demonstration projects, defense laboratories have been able to continue to both successfully compete for and retain top talent. The flexibility to offer more competitive compensation has greatly improved the ability to compete for top talent and the linkage of pay to performance has improved retention of top performers.

The greatest challenge has been how to implement these authorities in such a manner that they maximize the benefits without greatly increasing supervisory workload or negatively impacting motivation for any portion of the work force. This requires development of defendable policies and procedures and thorough education of the work force on exactly how they will be implemented. The other issue has been that different authorities granted to the different laboratories complicates the movement of personnel across the laboratories. Consistent with NDAA 2008, using the shared flexibilities now allowed will alleviate the perceived inequities.

Mr. SMITH. RADM Landay, there has been a proliferation of technology transition programs managed within OSD (S&T). For example, the Joint Concept Technology Demonstration (JCTD), Joint Experimentation, the Defense Acquisition Executive the Quick Reaction Fund, the Combating Terrorism Technology Task Force (CTTTF), the Technology Transition Initiative, the Foreign Comparative Test Program, and the Defense Acquisition Challenge Program. This does not include service specific technology transition and rapid acquisition programs. Yet, technology transition remains a perpetual challenge for the S&T community. a. What do you see as your top two technology transition challenges? b. Since 2001, many rapid technology development and fielding efforts have been put in place across OSD and the military departments. What steps have you taken to ensure that lessons learned from these rapid processes are being captured and institutionalized, as appropriate? c. Many of the efforts to rapidly transition technologies to the operational community to support the War on Terrorism have resulted in both developmental and operational test and evaluation of systems being conducted in theater. How is the S&T community collecting feedback from theater to ensure the appropriate improvements in capabilities are made and to also ensure that we don't continue to field systems with the same problems or limitations? d. What is your specific role at acquisition milestone decisions, with respect to Technology Readiness Assessments? How has this role changed in the last 2–3 years or how do you envision it changing in the future? e. What steps should the S&T community be taking to ensure that technologies identified as "critical" for major acquisition programs, are in fact sufficiently mature at the Systems Design and Demonstration (SDD) milestone?

Admiral LANDY. a. The top two technology transition challenges are (1) widespread closed/proprietary system designs and (2) the frequent encountering of a gap of as much as two years or more between completion of S&T and the initiation of an acquisition program contract. The first of these might well be addressed by the adoption by the DoN of an aggressive policy implementing an open system architecture (OSA) design approach in all of our acquisition programs. Without OSA we risk limiting the development process for many procurements to large systems houses, bidding against one another in ultimately a winner take all competition. The OSA design model, if done in particular in conjunction with an engaged Government engineering workforce, could enable the selection by potentially a better informed program manager of the best parts of the competing prototypes in the final product to be procured rather than having to select the overall single best value from the two prototypes. Furthermore, OSA development could enable engagement in the development process by a broader segment of industry since smaller and/or non-traditional suppliers might provide competitive proposed solutions for parts of the system being procured as opposed to having to have a viable, complete system solution. Strictly from a standpoint of inserting new technology into existing or under development systems, the OSA model is perceived as greatly enabling competitive innovations to be much more readily and affordably inserted into systems that might otherwise be locked down by a proprietary architecture controlled by one industrial house. The definition of open systems architecture, and Government owned interface standards, for a system can enable truly competitive refresh of parts or all of a system throughout its service life especially if there is a Government engineering team capable of performing, or at the very least, evaluating the integration and performing the test effort.

The second challenge is due to the risk averse culture imposed on our acquisition workforce. The acquisition program manager, and his/her related resource sponsor are generally reluctant to identify funding for transition of an inherently risky S&T product, knowing that S&T failure to complete successfully places the programmed acquisition funds at risk. The perceived prudent response is to delay programming of transition funding until such time as the S&T product is nearly successfully completed. In this case, the planning and programming lead time can introduce as much as a two year gap between completion of the S&T development and initiation of higher category transition funding. Delays in competing and award of an acquisition contract can add another year to this gap. ONR works closely with acquisition PMs and with their resource sponsors to keep them closely informed of the risk level of ongoing S&T programs. This interplay can lead to some reduction in the transition time gap. We have, moreover, put forth requests in the past for legislative changes that could enable reduction of some of the delay, normally associated with the acquisition contract competition and award, by allowing (legislative relief required) inclusion of an option on an S&T contract (initiated by either BAA or RFP) for further, prototype, development by an acquisition PM with acquisition funds. This latter approach could cut as much as a year off of the acquisition cycle and need not supplant the requirement for competitive award of any follow-on production contract.

b. The Office of Naval Research (ONR) has responsibility within the Department of the Navy (DoN) for management of many of these programs. We work closely with Office of the Secretary of Defense Director of Defense Research and Engineering (DDR&E) in identifying best practices across the military departments and are partners with OSD and the other services in a Technology Transition Executive Steering Group where these best practices are shared and process improvements are identified. We have run several Lean Six Sigma events aimed at both streamlining the process used in these programs as well as in better connecting with warfighter inputs to ensure that the highest priority products are selected.

c. ONR works closely with the warfighters and has had science and technology (S&T) members in theater for operational demonstrations of critical technologies. ONR requests and receives debriefs from the warfighters on the operational suitability and performance of S&T products being evaluated in theater.

d. The Chief of Naval Research has the responsibility within the DoN for the conduct of Technology Readiness Assessments (TRA) and the certification of Technology Readiness Levels for major acquisition programs. This has not changed over the last several years, nor is any change contemplated.

e. By the time of a TRA assessment it is too late in the process for the S&T community to address any shortfalls in the technology maturity of critical technology elements of a system under development. Early coordination between the acquisition community and the S&T community is required to avoid such problems. Recent developments, such as the assignment of Chief Technology Officer positions in the DoN Systems Commands have done a great deal to increase the level of communications required to avoid such problems and is expected to work to minimize them greatly in the future. See also notes in (a) above.

Mr. SMITH. In complex irregular warfare operations, technological superiority (big platforms) may not be an effective force multiplier. Instead, "soft" skills, such as languages, cultural awareness, information operations/psychological operations, and civil affairs may be required. a. How can technology help the U.S. military rapidly acquire the "soft" skills it needs to be effective in irregular warfare operations? b. How does technological superiority fit within today's threat environment?

Mr. JAGGERS. The Air Force recognizes the value of "soft" skills in addressing today's irregular and asymmetrical threat environment. Within its Science and Technology (S&T) Program, the Air Force has been researching and developing representations of human, social, culture, and behavior (HSCB) to determine their effects on aerospace operations. The intent of this research is to understand the perceptual and cognitive mechanisms used in an enemy's decision making process. The objective is to provide Airmen with the decision-aids, models, and simulations needed for planning and executing effective air operations. Combining these "soft" skills with modeling and simulation technologies will enable better forecasting of where conflict is most likely to occur, allowing more time to consider options and possibly increasing the chances that conflict might be prevented. The deeper understanding of enemy intent gained by identifying what aspects of HSCB are pertinent to military operations and developing capabilities to rapidly collect, exploit, and update this information will provide Airmen with the ability to act swiftly and decisively. "Soft" skills will not replace the need for technological superiority, but they can help reduce uncertainty in today's threat environment and enable our decision makers to respond with appropriate force.

Mr. SMITH. The DOD S&T Program is chartered, in part, to ensure the Department avoids technological surprise. Yet some may argue that DOD has been technologically surprised by IEDs, EFPs, and cyber warfare. What efforts does your organization undertake to avoid technological surprise? How are these different than they were five years ago?

Mr. JAGGERS. The Air Force maintains its technological superiority and adapts to address the new security environment of unconventional and non-traditional threats that faces us by continuing to rebalance and focus our core S&T competencies in response to these threats. The primary difference between now and five years ago is that we've modified the traditional Air Force "kill chain" of Find, Fix, Track, Target, Engage, and Assess to read **Anticipate,** Find, Fix, Track, Target, Engage, and Assess **Anything, Anywhere, Anytime** and have adopted this as our S&T vision to aid in focusing our efforts as we adapt to a new world environment. For example, we shifted investments in traditional areas to support the global war on terror by increasing emphasis in universal situational awareness as part of our Air Force tech vision to anticipate enemy actions. The goal is to develop a layered and flexible sensing architecture that responds to the Commander's intent by anticipating, detecting, continuously tracking, identifying, and precisely locating high value difficult targets. One area of particular interest and increased investment is the use of biotaggants that could revolutionize our ability to track weapons of mass destruction around the globe. As previously mentioned, the Air Force also recognizes the value of "soft" skills in addressing today's threat environment and, through such efforts as those in the areas of developing representations of human, social, culture, and behavior to better understand the enemy's decision making process, we should be better able to avoid technological surprise. By investing in a balanced S&T Program that addresses all Air Force mission areas, the Air Force is aggressively pursuing these and other high payoff technologies focused on countering the new threats of today, while modernizing our systems for tomorrow. These investments sustain the strong and balanced foundation of basic and applied research and advanced technology development needed to avoid technological surprise and support future warfighting capabilities.

Mr. SMITH. The DOD S&T Program investment strategy should balance the development of (a) technological countermeasures to perceived future threats, (b) technologies to create options for U.S. forces, and (c) technologies to shape our enemies' options. Could you provide some examples of investments you are making in each category and could you please discuss your vision for the appropriate distribution of investments for each category?

Mr. JAGGERS. The Air Force Science and Technology (S&T) Program investment strategy supports investments that provide countermeasures to future threats, options for our warfighters, and technologies to shape our enemies' options. Hypersonic technologies, such as the X–51, will provide stand off strike capabilities against the increasing depth of proliferating integrated air defense systems. Directed energy technologies will provide options for non-kinetic lethal (solid state laser) and non-lethal (active denial) capabilities needed by the warfighter in a variety of situations. Finally, Angel Fire is already providing 24x7, TiVo-like imagery to the warfighter impacting how our adversaries assemble, place, and detonate improvised explosive devices; increased investment in an all-weather, day-night persistent intelligence, surveillance, and reconnaissance technology called the GOTCHA Synthetic Aperture Radar will provide Angel Fire with even greater capabilities.

The Air Force guiding principle for investment in its Science and Technology (S&T) Program is to ensure the portfolio is properly balanced between near- mid- and far-term needs. This, in turn, supports our ability to address perceived future threats, create options for the warfighter, and to also shape or limit our enemy's options as reflected in the examples above. The proportion of basic research to applied research to advanced technology development in the S&T portfolio is largely driven by history and has served us well. However, keeping the right balance is always a challenge and we continually assess the S&T portfolio to ensure the right investment is in place. To ensure the Air Force is well-positioned to counter perceived future threats, we have set a goal of no less than 15 percent of core S&T funding be available for far-term basic research efforts. To address the more near-term needs of ensuring our warfighter has the means to Anticipate, Find, Fix, Track, Target, Engage and Assess Anything, Anywhere, Anytime, the goal is to allocate no less than 30 percent of core S&T funding for advanced technology development efforts. Transitioning technology into fielded weapon systems quickly can help us maintain an advantage over our adversaries. Toward this end, the Air Force has established a Technology Transition Office. This office is responsible for Advanced Concept Technology Demonstrations/Joint Capabilities Technology Demonstrations (ACTDs/JCTDs) and is also placing greater emphasis on utilizing Office of the Secretary of Defense rapid reaction efforts, such as Technology Transition Initiatives, Quick Reaction Funds, etc. with an eye on improving Air Force participation and success rates.

Mr. SMITH. The U.S. Special Operations Command FY09 S&T request is around $65 million this year which includes $11 million in a new area designated for SOF Information and Broadcast Systems advanced Technology. Can you briefly describe how the Special Operations S&T requirements fit into the overall DOD S&T planning process? Will we continue to see the SOF S&T budget grow to meet their unique mission challenges?

Mr. JAGGERS. As the Air Force Science and Technology (S&T) Executive, I have no real visibility into the planning, programming, budgeting, or execution of the U.S. Special Operations Command and defer to the Office of the Secretary of Defense with regards to how their requirements fit within the overall Department of Defense S&T planning process and expectations for future funding.

Mr. SMITH. Within the next year or so, several defense bases will begin closing and various activities will begin re-alignment including research and development activities within the defense laboratories. One of the greatest impacts of BRAC is loss of talented workforce. Certain key folks may not wish to uproot their families to move to another state. How will the affects of BRAC (workforce and others issues) impact your ability to provide the best capabilities for our warfighters? What mechanism have you put in place to minimize the potential impact?

Mr. JAGGERS. The Air Force is working to minimize the effects of upcoming Base Realignment and Closure (BRAC) actions; however, preservation of our intellectual capital is a very real challenge that could impact to some degree on our ability to provide the best capabilities for our warfighters. Current efforts being pursued to reduce these impacts include proactive force shaping, active recruiting, and retention initiatives. Significant new hiring of mobile personnel (i.e., personnel willing to relocate) is needed to allow new employees to train under the mentorship of highly experienced individuals who do not plan on relocating. An aggressive recruiting campaign is also underway to bring in a targeted set of new employees with a balanced mix of experience to fill positions ranging from bench scientists to seasoned technology leaders. We are focusing on university recruiting events, scientific conferences, and professional society meetings to identify key individuals fitting the mission, while using various intern programs to bring in undergraduate, graduate, and post-doctoral students to meet mission needs.

Mr. SMITH. There has been a proliferation of technology transition programs managed within OSD (S&T). For example, the Joint Concept Technology Demonstration (JCTD), Joint Experimentation, the Defense Acquisition Executive the Quick Reaction Fund, the Combating Terrorism Technology Task Force (CTTTF), the Technology Transition Initiative, the Foreign Comparative Test Program, and the Defense Acquisition Challenge Program. This does not include service specific technology transition and rapid acquisition programs. Yet, technology transition remains a perpetual challenge for the S&T community. a. What do you see as your top two technology transition challenges? b. Since 2001, many rapid technology development and fielding efforts have been put in place across OSD and the military departments. What steps have you taken to ensure that lessons learned from these rapid processes are being captured and institutionalized, as appropriate? c. Many of the efforts to rapidly transition technologies to the operational community to support the War on Terrorism have resulted in both developmental and operational test and evaluation of systems being conducted in theater. How is the S&T community collecting feedback from theater to ensure the appropriate improvements in capabilities are made and to also ensure that we don't continue to field systems with the same problems or limitations? d. What is your specific role at acquisition milestone decisions, with respect to Technology Readiness Assessments? How has this role changed in the last 2–3 years or how do you envision it changing in the future? e. What steps should the S&T community be taking to ensure that technologies identified as "critical" for major acquisition programs, are in fact sufficiently mature at the Systems Design and Demonstration (SDD) milestone?

Mr. JAGGERS. Recognizing the importance of transitioning technology into fielded weapon systems in a timely fashion, the Air Force established a Technology Transition Office focused on developing and implementing policies to overcome transition obstacles and facilitate the transition of technology in support of new concepts, programs of record, and fielded systems. The following answers are provided with regards to your specific questions:

a. The top two technology transition challenges facing the Air Force are codifying a strategic research and development plan and providing a sound pre-acquisition technical planning foundation to facilitate technology transition. There must be policies in place to address both development of technologies to support the Air Force's long-term strategic objectives and the transfer of these technologies into solid programs of record. Processes that include collaborative, early acquisition planning activities involving the Science and Technology (S&T), user, and acquisition communities are necessary to ensure each is familiar with and understands the potential of inserting promising technologies into planned or fielded weapon systems. A comprehensive programmatic and policy strategy across all 6.2 (applied research) through 6.7 (operational systems development) efforts is needed to ensure successful transition of technology and bridge the "valley of death." Our Technology Transition Office is currently integrating all transition assistance programs and creating seamless policy across laboratory technology development and product center acquisition systems engineering.

b. As noted, the Air Force has established a Technology Transition Office that serves as a central focal point for addressing matters in this important area, thus creating a synergy in technology transition efforts that more efficiently captures and institutionalizes lessons learned, matches solutions to needs, and revitalizes requirements planning and technology maturation.

c. The Air Force S&T community collects feedback from theater via our joint warfighting and intelligence operations. In addition, the Air Force Technology Transition Office is also directly involved with the warfighters through Joint Capabilities Technology Demonstrations and other rapid reaction programs, which provide additional insight into future capability needs, as well as lessons learned with regards to problems or limitations of fielded systems.

d. Per Department of Defense Instruction (DODI) 5000.2, Operation of the Defense Acquisition System, and National Security Space Acquisition Policy 03-01, Guidance for DOD Space System Acquisition Process, the Office of the Deputy Assistant Secretary of the Air Force (Science, Technology and Engineering) is directly involved in Technology Readiness Assessments (TRAs) for Milestones B and C, and Key Decision Points B and C, respectively. This responsibility extends to maintaining and overseeing the Air Force TRA process, and reviewing and endorsing TRA findings when the Milestone Decision Authority is either the Component Acquisition Executive or the Defense Acquisition Executive. This role has changed considerably over the last two to three years, as the TRAs are becoming institutionalized within the Air Force and I only expect it to grow in importance as TRAs are solidified as a critical part of the systems development process.

e. The S&T community's role in major acquisition programs past Milestone/Key Decision Point B is limited since current policy is for major acquisition programs to have their "critical" technologies at Technology Readiness Level 6 prior to Milestone/Key Decision Point B approval. However, some major Air Force acquisition programs are increasingly identifying technologies to be incorporated into future program blocks or upgrades at Milestone/Key Decision Point B, which the S&T community will help develop. In addition, the S&T community will most likely play a larger role in "critical" technologies as more major acquisition programs do a formal Milestone/Key Decision Point A.

Mr. SMITH. The mission of the Military Critical Technologies Program (part of the International Technology Security (ITS) office in DDR&E) is, in part, to identify technologies which contribute to, or have a potential to threaten, U.S. national security and to evaluate trends which might affect the availability of such technology. In addition, each of the services has Industrial Base Planning funds, to conduct studies of the health of the industrial base and to determine whether or not the industrial base continues to be able to provide military critical technologies. In the Office of the Secretary of Defense, the Industrial Policy office also conducts studies to ensure technological capabilities are sustained in the industrial base. Finally, the Manufacturing Technology program also seeks to improve the technological capabilities of the DOD industrial base. a. How are your Industrial Base Planning activities coordinated with those of the DUSD(Industrial Policy)? b. How are your Industrial Base Planning activities coordinated with your Manufacturing Technology programs?

Mr. JAGGERS. In response to question a., Air Force Industrial Base activities are worked in close coordination with the Office of the Deputy Under Secretary of Defense for Industrial Policy (DUSD(IP)). The Air Force coordinates Title I, Defense Priorities and Allocations System, activities through the Joint Industrial Base Working Group and participates on an ad hoc basis in Priorities and Allocation of Industrial Resources meetings led by DUSD(IP) to deconflict competing needs for limited national resources among the Services. In addition, the Air Force collaborates with other Office of the Secretary of Defense (OSD) organizations on Title ill and Title VII industrial base programs. In fact, the Air Force serves as OSD's Executive Agent for Title Ill, Defense Production Act, activities and works closely with the DUSD for Advanced Systems and Concepts (DUSD(AS&C)). In the case of Title VII, Committee on Foreign Investment in the United States, the Air Force works with the Defense Technology Security Administration by providing information to aid in determining whether the sale of U.S. firms to foreign entities may impact national security. In addition, the new Air Force Industrial Base Council (AFIBC) was formed to manage industrial base risks across the Air Force and to help guide industrial base investments in conjunction with DUSD(IP) studies to ensure technological capabilities are sustained in the industrial base. The AFIBC also provides support to the existing Department of Defense Space Industrial Base Council. Finally, the Air Force coordinates its Manufacturing Technology program with OSD and the other Services/Defense Agencies as a member of the Joint Defense Manufacturing Technology Panel.

In response to question b., with regards to coordination between the Air Force Industrial Base planning activities and its Manufacturing Technology program, the Air Force recognizes the close connection between these activities and responsibility for both lies with the Office of the Deputy Assistant Secretary of the Air Force (Science, Technology and Engineering).

Mr. SMITH. A recent DSB study on the Manufacturing Technology program recommended creating a Basic Research account for ManTech. The Navy already has a Manufacturing Science program. Do you agree with the DSB's recommendation? How would such a Basic Research effort within the ManTech program support the program's mission?

Mr. JAGGERS. The Air Force does not see a need to create a separate basic research program for Manufacturing Technology. Science and Technology (S&T) efforts in support of manufacturing technologies are pervasive across the S&T portfolio to include basic research. In addition, the Air Force is currently exploring the possibility of expanding its manufacturing technology basic research efforts by teaming a university with a contractor under the Small Business Technology Transfer program

Mr. SMITH. From an S&T perspective, which do you perceive as the greater threat to national security and to our military forces—endemic infectious diseases, such as influenza or HIV, or weaponized bio-terror agent, such as Plague? That is, which represents the greater threat and the greater S&T challenge?

Mr. JAGGERS. Medical research and development is centralized within the Defense Health Program. As the Air Force Science and Technology (S&T) Executive, I have no real insight into potential threats of a medical nature and defer to the Office of the Secretary of Defense with regards to whether endemic infectious diseases or the Plague represent the greater threat to our national security; however, the S&T challenges remain the same for all threats—proactively anticipating the use, countering an attack, and conducting forensics post-release of any biological agent into the homeland population.

Mr. SMITH. Current DOD and service laboratory and research, development, and engineering center facilities are located in a large number of locations. Many of these facilities are aging and either poorly equipped or the equipment is out of date. What is your assessment of the DOD science and technology infrastructure? What measures are needed and what measures are being taken to maintain the DOD science and technology infrastructure required to support the discovery and development of advanced technologies for the Department of Defense?

Mr. JAGGERS. Overall, Air Force Science and Technology research facilities are adequate to accomplish the mission. Maintaining or upgrading this infrastructure to support continued discovery and development of advanced technologies within the Department is primarily addressed within the Military Construction (MILCON) program—requirements are identified and compete for funding. We also have the flexibility to utilize a small portion of our Research, Development, Test, and Evaluation funding to upgrade our laboratory facilities. While there are challenges in prioritizing MILCON requirements—especially during a time of constrained budgets—the current process works and I do not believe additional measures are required to support a viable research program at this time.

Mr. SMITH. In previous years, Congress has enacted a number of pilot demonstration programs to provide more flexibility in the hiring practices, management, and conduct of the science and technology program in selected DOD agencies and the military department laboratories and research, development, and engineering centers. Have these authorities been useful? What are some of the challenges with implementing these authorities?

Mr. JAGGERS. The Air Force supports the Department of Defense's goal of one personnel system for its civilian workforce—the National Security Personnel System (NSPS); however, we also recognize the success the Air Force Research Laboratory (AFRL) has enjoyed in shaping its Scientist and Engineer (S&E) workforce through the flexibilities afforded by the Laboratory Personnel Demonstration System, commonly referred to as Lab Demo, and support AFRL's efforts while the current exemption remains in effect.

The authorities currently in use at AFRL have been extremely effective in many areas to include: providing management with greater control of the S&E workforce; generating increased levels of contribution among employees; providing management with the ability to set pay competitively when hiring highly qualified new employees; simplifying personnel processes, such as position classification; delegating personnel authorities to the Lab Director to speed decision making; and providing a positive impact on Lab culture. While AFRL initially received no hiring flexibilities through its demonstration project authority, Section 1107 of the Fiscal Year 2008 National Defense Authorization Act allows any of the demonstration laboratories to use other available Lab Demo authorities, including hiring flexibilities.

As AFRL and the other demonstration laboratories work with the Office of the Secretary of Defense (OSD) to develop a process for the laboratories to implement these authorities in a timely manner, the challenge lies in the sheer workload involved in developing proposals and vetting them through each of the laboratories, the Services, and OSD. They are also working with OSD on new initiatives that will enable the laboratories to continue to attract and retain much needed scientific experts.

Mr. SMITH. The mission of the Military Critical Technologies Program (part of the International Technology Security (ITS) office in DDR&E) is, in part, to identify technologies which contribute to, or have a potential to threaten, U.S. national security and to evaluate trends which might affect the availability of such technology. In addition, each of the services has Industrial Base Planning funds, to conduct studies of the health of the industrial base and to determine whether or not the industrial base continues to be able to provide military critical technologies. In the Office of the Secretary of Defense, the Industrial Policy office also conducts studies to ensure technological capabilities are sustained in the industrial base. Finally, the Manufacturing Technology program also seeks to improve the technological capabilities of the DOD industrial base. a. How are your Industrial Base Planning activities coordinated with those of the DUSD (Industrial Policy)? b. How are your Industrial Base Planning activities coordinated with your Manufacturing Technology programs?

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In response to question b., with regards to coordination between the Air Force Industrial Base planning activities and its Manufacturing Technology program, the Air Force recognizes the close connection between these activities and responsibility for both lies with the Office of the Deputy Assistant Secretary of the Air Force (Science, Technology and Engineering).

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Dr. KILLION. a. Army industrial base activities are coordinated most frequently with those of the DUSD (Industrial Policy) through regular staff contacts. Weekly and sometimes daily, staffs exchange questions and data in support of program managers and laboratories, as well as answering questions and developing policy in response to industry and congressional queries. Less frequently, the staffs meet in regular industrial base forums to discuss results of ongoing, more detailed studies and program efforts. Annually, the highlights of all of these efforts are reported to Congress in an OSD-prepared summary of industrial capability assessments. b. Army Industrial Base Planning activities are coordinated with our Manufacturing Technology efforts primarily at the government research laboratory level in support of both long range technology goals and shorter range program development activities. Critical technology events drive the development of weapons systems that lead to a key capability. These can originate in industry, in-house government labs, academia, or with international partners. The role of Army laboratories has been to act as clearing houses to ensure wide dissemination and coordination of technology efforts by: 1) collaborating with others; 2) evaluating performance of prototypes, including fixes for technical problems; 3) acting as consultants to contractors and to the Program Managers; and 4) acting as advisors to the Army to ensure a "smart buyer" capability.

This QFR was answered by Steven R. Linke, Army Industrial Base Policy, SAAL–PA

Mr. SMITH. A recent DSB study on the Manufacturing Technology program recommended creating a Basic Research account for ManTech. The Navy already has a Manufacturing Science program. Do you agree with the DSB's recommendation? How would such a Basic Research effort within the ManTech program support the program's mission?

Dr. KILLION. No, the Army does not agree with the DSB's recommendation that a basic research account be created for ManTech. However, as manufacturing processes push the limits of scientific knowledge, basic research on manufacturing science becomes imperative and is included with the current basic research portfolio. For example, investments that we are making in the area of biotechnology, which include self-assembly of materials into microstructures, enables new classes of manufacturing processes that have the potential to revolutionize the efficiency of production and the performance of the resulting functional and structural materials.

Mr. SMITH. From an S&T perspective, which do you perceive as the greater threat to national security and to our military forces—endemic infectious diseases, such as influenza or HIV, or weaponized bio-terror agent, such as Plague? That is, which represents the greater threat and the greater S&T challenge?

Dr. KILLION. The S&T challenges posed by endemic infectious diseases and bioterrorism are relatively equal. Plague and other potentially weaponized disease-producing organisms are often naturally occurring pathogens. The developmental pathways for medical countermeasures (drugs or vaccines) and diagnostics are similar for a disease-causing organism whether it is acquired as a consequence of natural exposure or as the result of the deliberate release in a bio-terror event (e.g., plague occurs in nature and is weaponizable). With regard to which represents the greater threat, certainly in the case of current operations, endemic disease contributes more to the lack of availability of Soldiers to perform operations than engineered biothreats.

Mr. SMITH. Current DOD and service laboratory and research, development, and engineering center facilities are located in a large number of locations. Many of these facilities are aging and either poorly equipped or the equipment is out of date. What is your assessment of the DOD science and technology infrastructure? What measures are needed and what measures are being taken to maintain the DOD science and technology infrastructure required to support the discovery and development of advanced technologies for the Department of Defense?

Dr. KILLION. From a review of the Army Headquarters Installation Status Report greater than 82% of the laboratory facilities have either a green or amber condition code that indicating that they are capable of meeting the laboratory requirements. Legislation such as Section 2804 of the National Defense Authorization Act for Fiscal Year 2008 (NDAA FY08) (PL 110–181) that amended 10 U.S.C. § 2805, and authorizes the Secretary of the Army to obligate and expend funds ($2M–$4M) for the revitalization and recapitalization of Army Laboratories through unspecified minor military construction projects, also contributes to our ability to maintain our facilities to meet future research and development needs. The rising costs of construction, however, will likely diminish the buying power associated with this legislation and require increases in the thresholds. In addition, over the last 5 years, the laboratories have spent approximately $500M for capital equipment. In the long term, the Army must exploit all of the authorities granted by Congress and demonstrate their usefulness if we are to maintain a vibrant and effective S&T infrastructure. Traditional military construction processes are unlikely to maintain technological competitiveness and are difficult for the S&T community to compete in due to operational priorities.

Mr. SMITH. In previous years, Congress has enacted a number of pilot demonstration programs to provide more flexibility in the hiring practices, management, and conduct of the science and technology program in selected DOD agencies and the military department laboratories and research, development, and engineering centers. Have these authorities been useful? What are some of the challenges with implementing these authorities?

Dr. KILLION. The pilot demonstration programs have been extremely useful to the Army laboratories and research, development and engineering centers (RDEC). The programs have enabled the Army to retain the best science and engineering talent by allowing initiatives, such as pay banding and streamlined hiring authority to enhance recruiting and reshaping of the workforce. These initiatives are unique to each laboratory allowing the maximum management flexibility for the laboratory directors and allowing them to be competitive with the private sector. The primary challenge with implementation of these authorities has been ensuring that the authority is delegated down to the laboratory/RDEC directors such that they maintain their management flexibility.

Mr. SMITH. Dr. Killion, there has been a proliferation of technology transition programs managed within OSD (S&T). For example, the Joint Concept Technology Demonstration (JCTD), Joint Experimentation, the Defense Acquisition Executive the Quick Reaction Fund, the Combating Terrorism Technology Task Force (CTTTF), the Technology Transition Initiative, the Foreign Comparative Test Program, and the Defense Acquisition Challenge Program. This does not include service specific technology transition and rapid acquisition programs. Yet, technology transition remains a perpetual challenge for the S&T community. a. What do you see as your top two technology transition challenges? b. Since 2001, many rapid technology development and fielding efforts have been put in place across OSD and the military departments. What steps have you taken to ensure that lessons learned from these rapid processes are being captured and institutionalized, as appropriate? c. Many of the efforts to rapidly transition technologies to the operational community to support the War on Terrorism have resulted in both developmental and operational test and evaluation of systems being conducted in theater. How is the S&T community collecting feedback from theater to ensure the appropriate improvements in capabilities are made and to also ensure that we don't continue to field systems with the same problems or limitations? d. What is your specific role at acquisition milestone decisions, with respect to Technology Readiness Assessments? How has this role changed in the last 2–3 years or how do you envision it changing in the future? e. What steps should the S&T community be taking to ensure that technologies identified as "critical" for major acquisition programs, are in fact sufficiently mature at the Systems Design and Demonstration (SDD) milestone?

Dr. KILLION. a. For transition of technology to traditional programs of record, the primary challenges are as follows. First, the technology developer must provide evidence of technology maturity and usefulness of the technology to satisfy a system requirement. Second, the acquisition program manager must have a need for the technology and a schedule and resources to support transitioning the technology. For the types of rapid transition programs mentioned above, the challenges are different. First, the technology must demonstrate sufficient robustness, safety, and efficacy to ensure that it is useful to Soldiers in the operational environment. Second, there must be sufficient documentation and program support to prepare Soldiers to use the system and to sustain its operation in theater.

b. The Army's Director for Technology represents Army interests in all of the OSD managed technology transition improvement and acceleration programs and processes. We provide input to the OSD led programs and maintain a close dialogue with OSD to obtain feedback on what processes work and/or how technology transition can be improved. In addition, my office maintains close working relationships with the technology developing commands to obtain feedback from the Lab's and Research Development and Engineering Center's efforts supporting fielded systems and the limited fielding of advanced technology. In this way we learn about issues related to new technology applications in current operations. Further, we have initiated a new effort to send personnel from my office to the Theater of Operations to provide direct assessments of issues related to fielding new technology.

c. The S&T community obtains feedback from fielded systems testing and supportability issues through their matrix support to the program managers of those systems who rely upon Labs and Research, Development and Engineering Centers to provide solutions to unforeseen problems. Additionally, the Army has formal processes to assess the performance of systems accelerated to the theater of operations and make decisions regarding their potential to become formal acquisition programs. For example, Research Development and Engineering Command (RDECOM) Labs and Centers participate in a weekly Current Operations Support Secure Video Teleconference and the theaters' Technology Solutions Secure Video Meeting. During these forums, representatives from RDECOM Labs and Centers, from the Navy and Air Force, and S&T advisors in-theater interface with warfighters in Iraq and Afghanistan to discuss materiel issues, including the performance and evaluations of recently fielded technologies. The Army Test and Evaluation Command (ATEC) is also major participant in forums that link the Army's Current Operations Support community with ATEC's Forward Operational Assessment Teams to ensure the technologies being evaluated meet operational needs, are supportable and safe. These operational assessments by theater provide valuable feedback to the developmental, acquisition and requirements generation communities. Issues and information from these venues, and others with the Training and Doctrine Command (TRADOC), seek to improve upon existing technologies and to ensure that future systems are not fielded with the similar problems or limitations.

d. My role in the acquisition milestone decisions is to evaluate program managers' technology maturity assessments and provide an independent certification of technology readiness to the milestone decision authority at Milestone B and Milestone C. This responsibility was established within the DOD 5000 instructions in 2002. Over the last several years, the major change has been the increased demand for application of this process across the full range of acquisition programs. For the future, I anticipate that the range of assessments that are required will expand (e.g., manufacturing readiness, software readiness, and integration readiness) and that we will be asked to make these assessments ever earlier in the concept development and system design and development process. There is concern that the growing numbers of assessments levied on acquisition programs may begin to impede progress vice facilitate technology transition. Our challenge is always to provide the appropriate amount of oversight without impeding the work of our acquisition community in providing capabilities to the Warfighter.

e. Since the requirement was established to conduct independent technology assessments, we have gained much experience in conducting these assessments and the program managers have implemented rigorous steps to perform their own technology maturity assessments. I believe that our current procedures are reasonably effective in identifying essential issues related to maturity of critical technology elements. An enduring issue is the availability of relevant data to substantiate claims as to the level of technology maturity. The S&T community must continue to work with the PEO/PMs to ensure that relevant and sufficient data are available from laboratory experimentation, field assessments, and formal testing. In addition, there needs to he clear documentation of the plans for technology development and demonstration supporting the program. In 2006, we established technology transition agreements as the authoritative document signed by both the technology developer and the acquisition program manager to align technology transition plans with systems development and demonstration schedules.

Mr. SMITH. Dr. Killion, what enhanced capabilities do flexible electronics bring to future ARMY/warfighter systems and what steps are the ARMY taking to incorporate this technology?

Dr. KILLION. Flexible electronics may enhance future Army/Warfighter systems by enabling novel form-factors, for example, curved focal plane arrays and sensors conformed to irregular shapes to more easily facilitate integration of electronics; larger size arrays, for example, sensor arrays with increased surface area giving enhanced capabilities for chemical and biological sensors; and lightweight and rugged electronics, for example, displays, sensors and power components.

The Army is currently examining the business case for investing in technologies to enable flexible electronics. We are already investing in related technologies through the Flexible Display Center (FDC) at Arizona State University and the FlexTech Alliance, formerly known as the United States Display Consortium. Long term visions for flexible electronics require improvements in thin film transistors (and related electronic elements) with improved operating reliability for advanced circuitry, sensors, focal plane array detectors, and drive electronics. The FlexTech Alliance, a consortium comprised of industry members, is enabling materials processing and tools for flexible displays and broadening the scope of application to flexible electronics.

Mr. SMITH. Dr. Killion, how does the S&T community synchronize the plans for projected systems to provide future force bandwidth needs to ensure they are sufficient to accommodate the capabilities of the systems they develop?

Dr. KILLION. Army Science and Technology works closely with the system developers throughout the system lifecycle. The Army S&T community continuously searches for better ways to meet program requirements for improved bandwidth, information throughput and spectrum usage. As new technologies emerge, the Army S&T community matures and demonstrates the technologies in coordination with the system developers and works closely to transition the technology for their use. Coincident with the synchronization plans, the Army S&T community is conducting network science research that will allow better prediction of network bandwidth needs and provide tools to optimize the network performance.

Mr. SMITH. In complex irregular warfare operations, technological superiority (big platforms) may not be an effective force multiplier. Instead, "soft" skills, such as languages, cultural awareness, information operations/psychological operations, and civil affairs may be required. a. How can technology help the U.S. military rapidly acquire the "soft" skills it needs to be effective in irregular warfare operations? b. How does technological superiority fit within today's threat environment?

Dr. KILLION. a. Technology can aid the military both in providing capabilities that supplement the Soldiers' abilities as well as in more rapidly and effectively preparing the Soldier for operating in such environments. For example, in terms of supplementing the Soldiers' abilities, the Army has worked with DARPA on language translation capabilities that reduce the need for the Soldier to have specific language skills. In addition, the Army is developing battle command decision support tools that enable decision makers to more effectively plan and execute operations in irregular warfare environments, taking into account factors such as religious affiliations, ethnic considerations, economic influences, etc. On the preparation side, an example is research at the Institute for Creative Technologies, at the University of Southern California, that focused on developing highly realistic, immersive environments that allow the Soldier to rapidly acquire the knowledge and skills such as cultural awareness and negotiation techniques needed in irregular warfare operations.

b. Even in irregular warfare environments, technological superiority is still a major factor in maintaining U.S. advantage and allowing our Soldiers to operate as efficiently and safely as possible. As an example, new sensor technologies have provided the commanders in theater with persistent surveillance/staring capabilities that allow continuous monitoring and tracking of threats across the battlefield. Additional technologies allow the surveillance information to be immediately communicated inside and outside of the theater for rapid response. Technologies such as lightweight armor for tactical vehicles, enhancements in situational awareness, nonlethal force application systems, and advanced training methodologies are just as relevant for irregular warfare as they are for traditional combat operations.

Mr. SMITH. The DOD S&T Program is chartered, in part, to ensure the Department avoids technological surprise. Yet some may argue that DOD has been technologically surprised by IEDs, EFPs, and cyberwarfare.What efforts does your organization undertake to avoid technological surprise? How are these different than they were five years ago?

Dr. KILLION. The challenges presented by IEDs, EFPs, and cyber warfare do not represent a technological surprise, with the possible exception of the scale in which they have manifested themselves.

From internal and external expertise, outside/independent studies, international technology mining, periodic reviews, etc., the Army has identified areas with great potential for developing new extraordinary and disruptive capabilities for our Soldiers. The Army S&T community works closely with Army Capabilities Integration Center (ARCIC), within the Army's Training and Doctrine Command, Materiel Developers and various intelligence centers to understand current and future threats. Since the beginning of OEF and OIF, weekly teleconferences with S&T representatives from each theater provide firsthand experience and insights to the evolution of the threats. Through these exchanges the Army S&T community gains insights on threat migration, capability, proliferation, and helps guide investments or accelerations of technologies as appropriate. Furthermore, Army S&T supports rapid transition of countermeasure and protection programs to support material developer's efforts to reduce risk to the soldiers and increase capability against emerging threats.

The greatest difference in the approach from five years ago is the increased interaction with the S&T representatives from the theaters that frame the research and development associated with the current threat. Another significant change is both the willingness and the speed with which technologies are inserted into the theatre of operations, effectively creating crucible for the continuous evaluation and enhancement of technological capabilities.

Mr. SMITH. The DOD S&T Program investment strategy should balance the development of (a) technological countermeasures to perceived future threats, (b) technologies to create options for U.S. forces, and (c) technologies to shape our enemies' options. Could you provide some examples of investments you are making in each category and could you please discuss your vision for the appropriate distribution of investments for each category?

Dr. KILLION. I can only speak for the Army, but examples of Army investments in each of these categories are as follows:

(a) Technological countermeasures to perceived future threats. The Army S&T community is investing in active protection systems (APS) to protect lighter weight combat vehicles from tank-fired threats. Research into APS sensor, interceptor, and guidance technologies is ongoing. We are also investing in new technologies such as high energy lasers that can address multiple missions such as the defeat rockets, artillery and mortars or unmanned aerial systems in order to protect our troops in the future. We are pursuing the development of new ballistic materials and armor designs, validating associated models that predict the fundamental material responses and overall ballistic performance, conducting ballistic performance evaluations and developing integration and manufacturing techniques to reduce costs and overall system weight. These armor designs are based on the projected future threats but also are used to address threats currently being seen in theater.

(b) Technologies to create options for U.S. forces. We are investing in technologies that create options such as the electromagnetic gun which has the potential to increase the range and effectiveness of large caliber weapons and directed energy weapons that can render enemy sensors and electronics ineffective. In addition, we are creating capability that can scale in it's delivered effects based on the situation encountered through our investments in non-lethal weapon technologies and scaleahle warhead technologies. We are exploring nano-technology which holds the promise of new materials for use as body armor and to increase performance. These nanostructures are assembled into macroscopic systems to produce materials and energetics with previously unattainable properties to dramatically enhance soldier survivability and weapon lethality.

(c) Technologies to shape our enemies' options. Perhaps one of the more significant game-change technologies is our commitment and investment in developing network centric warfare capabilities that help us better identify and address the threat, manned-unmanned teaming capability that enable the warfighter to extend his area of influence within the battlespace while reducing risk to his personal welfare, The development of wide area persistent surveillance creates a significant capability to modify the enemy's behavior as they are constantly under observation, but it creates significant challenges to include the sensor systems, real time processing of vast amounts of data, the real time interpretation of information for decision-making and challenging power and energy requirements to support such demanding systems. Efforts in biotechnology research will lead to totally new sensing systems, new ways for the rapid processing of data into information, the development of novel sense and response systems and biologically inspired power and energy solutions for our soldiers.

With regard to the appropriate distribution of investment across these categories, I believe that the majority of our investment should be in addressing the perceived/projected threats, as this is a key aspect of the Army S&T mission. In this regard, technologies that will enhance force protection of our troops are one of our highest priorities and largest S&T investment areas. Technologies that create options for the US and shape our enemies options are equally weighted in my mind—as they are intimately linked in many cases. The investments that are made within the S&T community are focused on maintaining US dominance as the premier land combat force in the world.

Mr. SMITH. The U.S. Special Operations Command FY09 S&T request is around $65 million this year which includes $11 million in a new area designated for SOF Information and Broadcast Systems advanced Technology.Can you briefly describe how the Special Operations S&T requirements fit into the overall DOD S&T planning process? Will we continue to see the SOF S&T budget grow to meet their unique mission challenges?

Dr. KILLION. SOCOM and SOF S&T do not fall under my authority, therefore I am unable to provide a response to your questions concerning their planning process or planned growth in their S&T budget. I respectfully recommend that this question be redirected to SOCOM for response.

Mr. SMITH. Within the next year or so, several defense bases will begin closing and various activities will begin re-alignment including research and development activities within the defense laboratories. One of the greatest impacts of BRAC is loss of talented workforce. Certain key folks may not wish to uproot their families to move to another state.How will the affects of BRAC (workforce and others issues) impact your ability to provide the best capabilities for our warfighters? What mechanism have you put in place to minimize the potential impact?

Dr. KILLION. As articulated in the December 28, 2007 report to Congress, the Army's move of the Communications Electronics Research, Development and Engineering Center (CERDEC) to Aberdeen Proving Ground greatly enhances operational support to the Global War On Terror (GWOT) and other contingency operations by creating a combined Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) technical and research facility with direct and valuable links to the Aberdeen Proving Ground (APG) test communities and ranges.

In planning for and implementing the Base Realignment and Closure recommendation to close Fort Monmouth, the Army diligently analyzed the human resources, facilities, information technology, and relocation phasing required to continue supporting the GWOT and other critical contingency operations. The Army defined the risks, developed strategies to mitigate those risks, and identified imperatives necessary to resource those strategies. In particular, the Army is reviewing a three pronged approach: a) increase the percentage of employees who relocate to

APG, MD by maximizing retention and relocation incentives and ensure that there is equity between APG and relocated employees to minimize employee shift between organizations; b) shift more hiring to APG prior to the closure of Fort Monmouth, NJ; c) accelerate hiring to backfill vacancies after the C4ISR mission moves to APG. With the continued and proactive support and resources from the Department of Defense and Congress, the Army will successfully execute the relocation from Fort Monmouth to Aberdeen Proving Ground by September 15, 2011 with minimum disruptions.

Mr. SMITH. A recent Defense Science Board (DSB) study on the Manufacturing Technology program recommended creating a Basic Research account for ManTech. The Navy already has a Manufacturing Science program. Do you agree with the DSB's recommendation? How would such a Basic Research effort within the ManTech program support the program's mission?

Mr. SHAFFER. The Defense Science Board (DSB) had ten major recommendations and numerous sub-recommendations. The Department has implemented many of the recommendations including a new Manufacturing Science and Technology (MS&T) program initiated by the Director, Defense Research and Engineering, in Fiscal Year 2008 to invest in cross-cutting manufacturing processes and provide early 6.3 manufacturing investment to concurrently mature manufacturing processes for emerging technologies. The program complements the Military Department ManTech programs, which tend to focus on program/platform specific issues. The Department has no current plans to establish a dedicated 6.1 Basic Research Manufacturing effort, but we have expanded the overall basic research program budget request by over 16% in our Fiscal Year 2009 request, and expect that some benefits to long-term manufacturing capabilities.

Mr. SMITH. From a Science and Technology (S&T) perspective, which do you perceive as the greater threat to national security and to our military forces - endemic infectious diseases, such as influenza or HIV, or weaponized bio-terror agent, such as Plague? That is, which represents the greater threat and the greater S&T challenge?

Mr. SHAFFER. Both foreign endemic diseases of military interest and bio-terror agents are significant S&T challenges and the Department cannot differentiate one or the other as a greater national security threat. We must invest in research addressing both. A strong science and technology (S&T) program in surveillance, prevention, diagnosis and treatment of infectious agents is critical for addressing ever-present (i.e., endemic) and potential (i.e., biowarfare) threats. Developing medical countermeasures to either will continue to take the concerted effort of the best medical scientists available. Some of these specific challenges are: (1) developing surveillance and medical interventions when the time course for identification and mitigation of these event/diseases is unknown or compressed; (2) developing the science base for understanding infection and disease processes so that broader acting medical countermeasures can be developed (in contrast to chasing the 'one bug, one drug' infinite continuum), (3) quarantine technology, capacity and procedures for unpredictable outbreaks of disease is limited; (4) the commercial 'market' for drugs and vaccines to counter disease pathogens that are not endemic to the US is minimal until an event occurs; and (5) there are significant barriers to executing human clinical trials for either threat.

Mr. SMITH. In previous years, Congress has enacted a number of pilot demonstration programs to provide more flexibility in the hiring practices, management, and conduct of the science and technology program in selected DOD agencies and the military department laboratories and research, development, and engineering centers. Have these authorities been useful? What are some of the challenges with implementing these authorities?

Mr. SHAFFER. The pilot demonstration authorities were useful. They have permitted the Department to evaluate alternative personnel system approaches which include pay banding; simplified classification; performance-based compensation; streamlined hiring and staffing processes; expanded development programs (sabbaticals and degree training); and modified reduction-in-force procedures which take performance into account.

Challenges in implementing these authorities include ensuring open communication about the alternative approaches with the workforce and workforce representatives; providing comprehensive training for senior leaders, supervisors, and staff, ensuring that stakeholders are actively involved in the design, development and implementation of the program; putting in place comprehensive planning processes for implementation, providing mechanisms for assessing status and managing risk; and developing an assessment plan which will enable evaluation of the effectiveness of the demonstration projects and alternative personnel systems.

Mr. SMITH. The Department's missions have expanded to include stability operations, humanitarian assistance, reconstruction and other activities that touch upon the jurisdiction of other federal agencies. Issues that are much broader than the scope of this subcommittee. Mr. Shaffer, how are the DOD's S&T efforts-planning, developing, and transition of technologies that are supportive of the growing mission as I just described collaborated/integrated with other agencies such as State, DHS, Justice and others?

Mr. SHAFFER. First, it is important to note that the Office of Science and Technology Policy Committee on Homeland and National Security has been reinvigorated this summer. This committee is co-chaired by senior DOD and Department of Homeland Security leaders, and is specially chartered to coordinate activities across government agencies. Recently, this committee gave its approval to a stability operations technology roadmap.

But we recognize the need to focus specifically on interagency collaboration, and have re-chartered the science and technology component of the former Office of Force Transformation earlier this year to undertake interagency science and technology efforts. This is beginning to bear fruit. We will cite just a couple of examples. We are nearing completion of a series of interagency workshops focused on how we can apply a "whole of government" approach to dealing with transitional law enforcement operations in a stability and reconstruction environment. With DOD, Department of State, Department of Homeland Security, and Department of Justice participation, we will use the results to identify science and technology needs as well as organizational models compatible with our system of government. We have undertaken new interagency science and technology efforts as well. In conjunction with NASA, we have begun development of a prototype air vehicle which will drastically reduce fuel and infrastructure requirements needed for aerial logistics missions. With such a vehicle, our ability to conduct humanitarian assistance, both at home and abroad, would be significantly improved over what is available today.

Additionally, we have redirected several of our existing programs to focus on interagency requirements. For instance, we recently completed a successful Caribbean drug interdiction operation in conjunction with Department of Homeland Security in which law enforcement officers embarked upon a DOD experimental vessel. We also recently reached agreement with the Department of Homeland Security to cooperatively test and develop small unit command and control capabilities in support of border security operations.

In the areas of stability operations and reconstruction, we hosted an interagency workshop in June to look at the breadth of analytical tools available to aid reconstruction efforts in Afghanistan, including participants from the U.S. Army Corps of Engineers, United States Agency for International Development (USAID), U.S. Institute for Peace, the State Department, and the U.S. Geological Survey. Finally, we are beginning a science and technology development effort in conjunction with members of the interagency intelligence community to better understand the challenges of multi-platform/multi-sensor intelligence collection, fusion, and analysis. As we go forward, we intend to search for additional opportunities to collaborate on interagency science and technology projects. The results of each of the efforts highlighted above—as well as others we undertake in the future—will be available to all members of the interagency community for evaluation and technology transition in accordance with the unique requirements and processes of the individual departments and agencies.

Mr. SMITH. Mr. Shaffer, there has been a proliferation of technology transition programs managed within the Office of the Secretary of Defense for Science and Technology. For example, the Joint Concept Technology Demonstration (JCTD), Joint Experimentation, the Defense Acquisition Executive the Quick Reaction Fund, the Combating Terrorism Technology Task Force (CTTTF), the Technology Transition Initiative, the Foreign Comparative Test Program, and the Defense Acquisition Challenge Program. This does not include service specific technology transition and rapid acquisition programs. Yet, technology transition remains a perpetual challenge for the S&T community

a. How do you avoid duplication in these programs and why does OSD need so many authorities for technology transition efforts?

b. What do you see as your top two technology transition challenges?

c. Since 2001, many rapid technology development and fielding efforts have been put in place across OSD and the military departments. What steps have you taken to ensure that lessons learned from these rapid processes are being captured and institutionalized, as appropriate?

d. Many of the efforts to rapidly transition technologies to the operational community to support the War on Terrorism have resulted in both developmental and operational test and evaluation of systems being conducted in theater. How is the S&T community collecting feedback from theater to ensure the appropriate improvements in capabilities are made and to also ensure that we don't continue to field systems with the same problems or limitations?

e. What is your specific role at acquisition milestone decisions, with respect to Technology Readiness Assessments? How has this role changed in the last 2–3 years or how do you envision it changing in the future?

f. What steps should the S&T community be taking to ensure that technologies identified as "critical" for major acquisition programs, are in fact sufficiently mature at the Systems Design and Demonstration (SDD) milestone?

Mr. SHAFFER. In the Department's 2007 Research and Engineering Strategic Plan, we highlighted several high-level management principles. Among the most prominent was the principle to "Transition Technology to Acquisition Programs and the Warfighters." This principle—to mature technology for use in acquisition programs and, better yet, by operational units and our soldiers, sailors, airman and marines—is a guiding principle for the DOD research and engineering program. Unfortunately, the business processes in place within the federal government and Department sometimes lack the agility or flexibility to easily transition technology. This shortfall has been highlighted in numerous recent blue-ribbon panels, each of which has recommended alternatives to enhance transition. This proliferation of studies and recommendations has, I believe, resulted in a proliferation of programs to fix parts of the problem. This may or may not be appropriate, because the challenge of technology transition is complex and we have not identified a "one size fits all" solution. Consequently, the DOD has generated a number of complementary programs to address specific technology transition challenges. We self-generated some of these programs, such as the Joint Capabilities Technology Demonstration program and the Defense Acquisition Executive program. Some of the programs have been congressionally mandated, such as the Technology Transition Initiative and the Defense Acquisition Challenge Program. By using the different tools of the various programs, we can frequently find a more direct path to transition.

For the most part, we have avoided unintended duplication by working to define unique domains, or programmatic characteristics, for each program. We will illustrate with an example. Within the Office of the Director, Defense Research and Engineering (DDR&E), we generated a program in 2003 called the Quick Reaction Special Projects (QRSP) Program. We designed this program to demonstrate capabilities rapidly within 12 months if possible. This 12 month cycle is important because the standard budget process within the DOD is 18–24 months, so QRSP works within the budget cycle. QRSP provides the agility needed in a world with rapid technology maturation. Within the QRSP, we have two complementary projects: the Rapid Reaction Fund (RRF; formerly known as the Combating Terrorism Technology Task Force) and Quick Reaction Fund (QRF). The Rapid Reaction Fund is used to address "irregular Warfare," while the QRF is used to address conventional capabilities. In those instances where high priority capability needs overlap, the programs can share funding. Both programs are thoroughly vetted with the Combatant Commanders, and address real world needs. Because of the short time scale and flexibility provided by these programs, they are considered as the two highest priority programs in DDR&E. Because we have involved the warfighters in the program and both deliver demonstrable capabilities, we receive real world feedback from the warfighters who assess the technology in a warfighting environment.

In addition, we are in the process of rechartering the Technology Transition Executive Steering Group, made up of Science and Technology Acquisition Senior Executives from each service. The oversight from this group will also minimize unintended duplication.

The on-going technology transition programs supplement our routine interaction with the acquisition community, an interaction that has been strengthened in the past several years. Much of this strengthened relationship has occurred because we are now required to provide a technology maturity—assessment of critical technology elements in conjunction with a milestone B decision. Before a program enters System Design and Development, the DDR&E team evaluates the technology maturity thereby enhancing transition of matured technologies. This process, as it matures, should help ensure we transition mature technology.

Finally, it is important to also recognize that we need to continually rationalize the DOD technology transition effort, and have created a position to develop and oversee innovative approaches to Department-wide transition. This position, the Assistant Deputy Under Secretary of Defense for Innovation and Technology Transition, is a Senior Executive Service level position created to examine how the Department can more effectively transition technology and to provide a policy focus to the challenges. The ADUSD (I&TT) interacts on a routine basis with the Military Departments through the Technology Transition Executive Steering Group, which is made up of senior-level representatives from both the S&T and acquisition communities, to improve and strengthen the execution of technology transition to meet our warfighters' needs through sharing of best practices.

Effective technology transition has been, and remains, a contact sport. The apparent proliferation of programs cited in the question merely provides the tools to support the contact. There are challenges, and I am not comfortable citing two as the "top two". Working in tandem with the acquisition and requirements community, we are addressing the challenges in a systemic way.

Mr. SMITH. How can the Military Critical Technologies Program hope to be relevant if it only conducts its assessments on a three-year cycle? For example, how many new technologies are now in use by the mainline U.S. military that were not in use three years ago?

Mr. SHAFFER. Since the pace of global technology development is accelerating, the Department has changed its Military Critical Technologies List (MCTL) process over the last two years to one of essentially continuous updating and publishing. As a basic management goal, all sections of the list are now updated at least every two years, with a desired goal of every year. This was enabled by the adoption of an on-line, wiki-based environment for use by our Technology Working Group (TWG) development teams, and the introduction of on-line publishing of the updated list sections via the Defense Technical Information Center (DTIC.) The rate of progress varies greatly in differing areas of technology, and thus a single time requirement is not adequate or reasonable for all technologies. Significant developments in the technology base of a given area can now trigger revisions regardless of the age of the existing sections, and publishing of revised sections is accomplished whenever changes are staffed and complete, rather than on an annual basis as was the previous practice.

Mr. SMITH. What is the role of the International Technology Security (ITS) office in providing input to the Office of the Secretary of Defense for Policy and International Security Policy for the CFIUS (Committee on Foreign Investment in the United States) process? How is that contrasted with the role of the Deputy Under Secretary of Defense for Science & Technology? How accurate can such input be if it's provided on the basis of a process with a 3-year update cycle?

Mr. SHAFFER. As a part of the Office of the Director of Defense Research & Engineering (DDR&E), ITS reviews and comments on all CFIUS cases, via coordination accomplished within the office of the Under Secretary of Defense for Acquisitions, Technology and Logistics by the office of the Deputy Under Secretary of Defense for Industrial Policy. Individual cases are reviewed by ITS for technology listed on the MCTL, and where listed technologies exist, ITS Technology Working Group subject matter experts can comment on the potential need for protection of technologies. Subject matter experts from the Office of the Deputy Under Secretary of Defense for Science & Technology, along with other appropriate organizations, also comment directly to the Office of the Deputy Under Secretary of Defense for Industrial Policy (IP).

Mr. SMITH. How does the ITS office's role differ from the role of the Office of the Deputy Under Secretary of Defense for Industrial Policy (DUSD(Industrial Policy))?

Mr. SHAFFER. ITS, in its role constructing the MCTL, is charged with identifying specific technologies of military criticality to inform the Commerce Department's dual-use export control process. This task is narrowly focused, and is centered on protecting against the spread of technologies which may be used to harm the US or American interests. Industrial Policy's (IP) focus is much broader. The IP mission is to sustain an environment that ensures the industrial base on which the Department of Defense (DOD) depends is reliable, cost-effective, and sufficient to meet DOD requirements. It does this by (1) monitoring industry readiness, competitiveness, ability to innovate, and financial stability; (2) ensuring DOD research and development, acquisition, and logistics decisions promote innovation, competition, military readiness, and national security; and (3) leveraging statutory processes (for example, the Defense Priorities and Allocations System, Hart-Scott-Rodino antitrust evaluations, Exon-Florio Committee on Foreign Investment in the United States evaluations) to promote innovation, competition, military readiness, and national security.

Mr. SMITH. In complex irregular warfare operations, technological superiority (big platforms) may not be an effective force multiplier. Instead, "soft" skills, such as languages, cultural awareness, information operations/psychological operations, and civil affairs may be required. a. How can technology help the U.S. military rapidly acquire the "soft" skills it needs to be effective in irregular warfare operations? b. How does technological superiority fit within today's threat environment?

Mr. SHAFFER. In his November 26, 2007 speech at Kansas State University, Secretary Gates called for a paradigm shift, away from solely military operations, more towards the ". . . civilian instruments of National Security diplomacy, strategic communications, foreign assistance, civic action and economic reconstruction and development." In response to the direction of the Secretary, the department has increased focus on "Soft Power." The Science and Technology (S&T) community is leading with changes in investment priorities.

Technology superiority remains a center of gravity in current conflicts and will likely continue to do so in the future. However, the construct for technology superiority is expanding to include domains like sensors, information fusion, and human, social, culture and behavioral modeling. The Department's S&T program has expanded in each of these areas. The concept of Irregular Warfare describes conflicts fought not with large military formations, but with small numbers of forces in conjunction with force multipliers that can only come through technological innovation. Today, with the priority given to "Soft Power," technological investments are being made that deliver greater capability to the warfighter in the areas noted by the Secretary above. The Director, Defense Research and Engineering (DDR&E), established a multi-year "Human, Social, Cultural and Behavior" initiative and supporting roadmap. Fiscal Year 2008 was the first year of this initiative.

Additionally, DDR&E is charged with developing innovative capabilities for the warfighter in a non-traditional, rapid manner and has been investing in "Soft Power" technologies at an ever-increasing rate. In June of this year, we sponsored a workshop focused on the reconstruction and stability of Afghanistan, with invitees such as Department of State (DoS), United States Agency for International Development (USAID), and Gallup. The rationale was to examine how DOD, DOS, Non-Governmental Organizations, and others can share the requirements of "Soft Power" and leverage resources appropriately. DDR&E also sponsors a Strategic Multi-Layer Assessment (SMA) program. The SMA program is charged with bringing together social scientists to study specific problem areas, not from a military perspective, but from one that brings together personnel with expertise in economics, sociology, psychology, history, culture, and other areas to reframe the problem set and recommend innovative actions that affect areas often disregarded in traditional "hard power" projection scenarios.

Mr. SMITH. The DOD Science and Technology (S&T) Program is chartered, in part, to ensure the Department avoids technological surprise. Yet some may argue that DOD has been technologically surprised by IEDs, EFPs, and cyber warfare. What efforts does your organization undertake to avoid technological surprise? How are these different than they were five years ago?

Mr. SHAFFER. A key mission of the DOD S&T program is to minimize technology surprise to the DOD, and balance with other development efforts. As such, the department made continued strides since 2003 (5 years ago) when the term disruptive technology was often followed by recitation of the three emerging technology pillars of nano-technology, bio-technology and information technology. We have matured our thinking about disruptive technologies, and now include application of commercial capabilities.

At a macro level, starling in 2002 the Department took action to further reduce the risk of technology surprise by putting in place processes, initiatives and information technology solutions to better integrate the intelligence community into the DOD S&T planning process and enable rapid transition of technology where needed to short circuit emerging technology risks. We have used quick reaction funds to allow us to rapidly understand newer technology areas and matured technology intelligence analysis. Finally we are expanding our footprint in global technology "prospecting" by expanding global outreach. All totaled, we are spending more time and effort to understand foreign technology than we did five years ago.

Mr. SMITH. The DOD S&T Program investment strategy should balance the development of (a) technological countermeasures to perceived future threats, (b) technologies to create options for U.S. forces, and (c) technologies to shape our enemies' options. Could you provide some examples of investments you are making in each category and could you please discuss your vision for the appropriate distribution of investments for each category?

Mr. SHAFFER. DOD's Science and Technology (S&T) program makes substantial investments in each of these categories and seeks to balance our program across all three. Examples of countermeasures include research into cyber-security to protect networks and information system infrastructure from attack and compromise, research on stand-off detection and neutralization of nuclear materials, and research on active protection systems to engage rockets and missiles fired at ground vehicles.

Technology to provide options include research in hypersonics to enable very rapid interdiction at great distances, research on high energy lasers for platform defense, and research in compact, portable electrical power sources to enable agile and sustainable operations by dismounted forces.

In the third category, the Department is investing in research in biomedical sciences to develop countermeasures for contagious diseases and toxins, thereby denying terrorists one of their most threatening attack vectors, and research in energetic materials for penetration of hard and deeply buried targets to put an adversary's underground facilities at risk.

In an uncertain world, a balanced research investment portfolio balances efforts both in these categories and in other areas such as wounded warrior care, current threats (e.g., IEDs), and sustaining foundational sciences. DOD's S&T enterprise conducts annual strategic reviews of the investment portfolio to align investment priorities with technological opportunities and operational needs, either current or projected. In addition, we have increased the emphasis on technology intelligence analysis to better inform the balance of threats, options for U.S., and options to share potential adversary options.

Mr. SMITH. The United States Special Operations Command (USSOCOM) Fiscal Year 2009 (FY2009) Science and Technology (S&T) request is around $65 million this year, which includes $11 million in a new area designated for Special Operations Forces (SOF) Information and Broadcast Systems Advanced Technology. Can you briefly describe how the SOF S&T requirements fit into the overall Department of Defense S&T planning process? Will we continue to see the SOF S&T budget grow to meet their unique mission challenges?

Mr. SHAFFER. The SOF Information and Broadcast Systems Advanced Technology program element (1160472BB) was established in Fiscal Year 2009 to separately capture S&T efforts related to information and broadcast technology. This program element contains the Psychological Operations (PSYOP) Global Reach (PGR) and PSYOP Modernization programs. Beginning in Fiscal Year 2009, existing PGR Advanced Concept Technology Development (ACTD) resources ($4.970 million) were realigned from Program Element 1160402BB, Special Operations Advanced Technology Development. The additional $6.020 million for PSYOP Modernization was resourced through internal funding realignments during the Command's budget process.

The SOF S&T process is fully integrated with the overall DOD S&T program. Representatives from USSOCOM are integral players in the annual comprehensive S&T review process, whereby all components with S&T investment brief their requirements and plan to address the capability needs. This review occurs each year in January as a start to the DOD budget development process.

USSOCOM's S&T strategy is to selectively invest and leverage available resources with the Military Departments and other agency laboratories, academia, and industry for the purpose of maximizing SOF capabilities. USSOCOM's involvement in several ACTDs and Joint Capability Technology Demonstrations allows USSOCOM to leverage the resources of other organizations to create robust opportunities for evaluating and transforming mature technologies in a way that the command could not otherwise afford within its limited S&T budget. One example of partnership success was close coordination between USSOCOM and the Director, Defense Research & Engineering on tagging, tracking, and locating technology investments.

Mr. SMITH. In complex irregular warfare operations, technological superiority (big platforms) may not be an effective force multiplier. Instead, "soft" skills, such as languages, cultural awareness, information operations/psychological operations, and civil affairs may be required. a. How can technology help the U.S. military rapidly acquire the "soft" skills it needs to be effective in irregular warfare operations? b. How does technological superiority fit within today's threat environment?

Dr. TETHER. I think the DOD has become more aware of the need for what you term "soft skills" in response to the irregular warfare and operations in Iraq and Afghanistan. People in all the Services and OSD are rethinking what is needed to succeed in those situations.

But I would say that technology can help meet those challenges. It's worth remembering that our technological capabilities are one of our asymmetric advantages.

Much of what we work on is aimed at getting better information about the enemy and then acting more quickly and precisely. Better information and decision making will help make our use of force, when needed, more subtle and less likely to cause collateral damage.

And, we have a number of programs aimed directly at soft skills:

- Our array of language translation programs will improve our understanding of what is going on throughout a society and allow us to work better with the locals.

We made a language training program available that includes gestures and social conventions to reduce what might be called "cultural friction."

- Our ASSIST program is helping our troops on the ground better gather, store and share information about the neighborhoods they work in. This "cop on the beat" type of information will improve our understanding and partnerships with locals.
- Our Integrated Crisis Early Warning System (ICEWS) program is working to create a system that not only helps forecast instability in a society but provides commanders with diplomatic, economic or military options for preventing or reducing the crisis. Softer options are an integral part of it.

Mr. SMITH. The DOD S&T Program is chartered, in part, to ensure the Department avoids technological surprise. Yet some may argue that DOD has been technologically surprised by IEDs, EFPs, and cyberwarfare. What efforts does your organization undertake to avoid technological surprise? How are these different than they were five years ago?

Dr. TETHER. I don't agree that those items constitute technological surprises to DOD. Cyber warfare is something DARPA and others in DOD have been aware of and working to counter for many years. Similarly, EFPs are a technology DOD was aware of before they were used in Iraq. IEDs are an interesting case. But even here DOD had concepts of using smart mines which were along side the road and triggered by vehicles passing by.

On the other hand, IEDs are definitely an operational surprise in both their effectiveness and in constraining freedom of movement. The technology needed for IEDs is fairly simple and commonly available—which is partly why they are so difficult to counter.

But you are correct that DARPA's mission is to prevent the technological surprise of the US. We have also learned that the best way to prevent surprise is to be constantly creating it. The key to this is to constantly search the technological frontier for new ideas and discoveries. The best way to do that is to continually bring in new people who are leaders in their field, know what is on the cutting edge, and have good ideas on how to use new discoveries. While information on technological and scientific developments is helpful, the real way DARPA stays on the technological frontier is through its policy of rotating program managers. Knowledgeable, creative, entrepreneurial people prevent technological surprise far better than just information.

Our policy of rotating personnel also makes it easy for us to change focus and direction. If we want to go in a new direction, then we start hiring people in that area as other people leave. And, in the last several years, we have become more interested in countering asymmetric threats.

Finally, there are plenty of good ideas overseas too. Part of what I've done as Director is travel to places like India, Israel, Australia, Sweden and Singapore to understand the technical developments, capabilities and opportunities in those nations. Preventing and creating technological surprise requires an awareness of what might be happening around the globe.

Mr. SMITH. The DOD S&T Program investment strategy should balance the development of (a) technological countermeasures to perceived future threats, (b) technologies to create options for U.S. forces, and (c) technologies to shape our enemies' options. Could you provide some examples of investments you are making in each category and could you please discuss your vision for the appropriate distribution of investments for each category?

Dr. TETHER. In terms of countermeasures, perhaps our most obvious work is in biological warfare defense. If we succeed in finding ways to rapidly develop and manufacture therapies for any pathogen, including entirely new ones, it would neutralize or at least enormously limit the value of any biological attack. In our Space strategic thrust we developing technology to better understand what threats might be present on-orbit and to protect our space assets. We are looking at ways to detect and characterize underground structures and are very active in the area of cyber security. These are just a sample.

In terms of creating new options for US forces, our research in Advanced Manned and Unmanned systems promises a variety of new platforms to carry out missions in new ways, many of them autonomously. In our Space thrust, Orbital Express demonstrated the autonomous refueling of satellites on-orbit. Our research in Robust, Secure Self-Forming Networks aims to let DOD reach the full potential of network-centric operations, and we continue to improve our ability to find, track and destroy elusive targets. The wellspring for many of these new capabilities and option is our long-standing research in core technologies like materials and information technology—the improved technologies that allow us to create systems.

Because armed conflict requires at least two parties, all of these options shape our potential enemy's options as well, hopefully in such a way that they are dissuaded from a fight. Reducing our threats reduces their options, whereas new options for us increases the threats to them and indirectly reduces their options. But, as history shows, we should expect threats and countermeasures to evolve with each other over time.

We have no particular rules of thumb for such investments since we really don't pre-allocate funds but respond to ideas and count up the resources later. The ideas we fund however depend on the particular strategic environment and circumstances at that time. What exactly are the threats you face? What are the opportunities that you might seize? One cannot decide what to invest in without considering those factors and weighing them against each other—and they are always changing.

Mr. SMITH. The U.S. Special Operations Command FY09 S&T request is around $65 million this year which includes $11 million in a new area designated for SOF Information and Broadcast Systems advanced Technology.Can you briefly describe how the Special Operations S&T requirements fit into the overall DOD S&T planning process? Will we continue to see the SOF S&T budget grow to meet their unique mission challenges?

Dr. TETHER. I can't really speak to the Special Operations Command's (USSOCOM) budget and planning process, but I would like to highlight our excellent on-going partnership with USSOCOM.

Over the past several years, DARPA has established a "special relationship" with USSOCOM. Why? I regard them as DARPA's test lab, where we can test new technology and hear what works and what doesn't from some of the most sophisticated operators in the DOD. Working with highly demanding "first adopters" is one the best ways to ensure your new technologies are indeed revolutionary. We get to hear their most pressing challenges, to excite our researchers to move into new areas and explore new solutions. On the other hand, we give then an opportunity to get insight into future technologies and even try some of them.

DARPA and USSOCOM complement each other well; our missions, capabilities and even our cultures of being fast and flexible are an excellent fit. DARPA has had a full-time representative at USSOCOM in Tampa for 6 years. I sent her there to make sure USSOCOM hears about our technologies, has the opportunity to test and evaluate them, and can cherry-pick what best fits their needs. We benefit by their testing and use of our prototypes; when we solve USSOCOM's challenges, we often meet those for the services as well. We also benefit when she brings back difficult challenges for our researchers at DARPA. It's been very fruitful for all of us.

Mr. SMITH. From an S&T perspective, which do you perceive as the greater threat to national security and to our military forces—endemic infectious diseases, such as influenza or HIV, or weaponized bio-terror agent, such as Plague? That is, which represents the greater threat and the greater S&T challenge?

Dr. TETHER. Clearly, endemic infectious diseases can threaten our military effectiveness. There are many examples from history when illnesses like dysentery or malaria have put entire fighting units out of action. Some of what DARPA has been working on in our Bio-Revolution strategic thrust is applicable to preventing and treating endemic diseases. Our Rapid Vaccine Assessment program aims to rapidly identify effective vaccines; the Accelerated Manufacturing of Pharmaceuticals program is pursuing new technologies to manufacture large quantities of therapeutics against any pathogen within 12 weeks. Another DARPA program worked on preventing disabling diarrheal diseases.

As part of DOD, our primary focus must be on militarily relevant threats. We must protect our troops against threats unique to the military and effectively treat them when needed. Our troops face threats from weaponized bio-agents and they deploy to regions where rare tropical diseases can be commonplace, so we must protect them against both exotic natural pathogens and those made highly virulent by our adversaries. The DOD must address those military specific threats, as no other organization has the responsibility or incentive to do so. Conversely, there are many other organizations, public and private, across the world, whose mission or market opportunity is to fight commonly occurring natural infectious disease. For example, NIH and pharmaceutical companies have either the mission or market opportunity to fight those common diseases. But for weaponized bio-agents and exotic diseases that our troops might confront, DOD must solve the problems. It's no one else's mission and there is not enough on-going market for most of the drugs needed to keep private firms interested.

Mr. SMITH. In previous years, Congress has enacted a number of pilot demonstration programs to provide more flexibility in the hiring practices, management, and conduct of the science and technology program in selected DOD agencies and the military department laboratories and research, development, and engineering centers. Have these authorities been useful? What are some of the challenges with implementing these authorities?

Dr. TETHER. These authorities have been extremely useful and are absolutely invaluable to us. We strongly support the flexible hiring authorities DARPA has been using and their continuation.

The lifeblood of DARPA is new ideas, and the best way to get new ideas is to bring in new people. This requires the flexibility to quickly hire great people with great ideas by offering competitive compensation. Without this kind of flexible hiring authority, DARPA's access to new people and new ideas would quickly be greatly diminished.

The landmark authority in this area for us was the "Section 1101" authority given to DARPA in the FY 99 National Defense Authorization Act and subsequently extended to other agencies; this authority expires in Sept 2011. Section 1101 was the model for the "Highly Qualified Experts (HQE)" authority (5 USC 9903) permanently given to the entire DOD as part of the National Security Personnel System. DARPA has used both these authorities extensively, but now emphasizes using the HQE authority.

The great difficulty in implementing these authorities, particularly as they have become more available throughout the DOD, is resisting the constant temptation to make them like the standard system. At first, these authorities stand out because, by design, they don't have as many of the rules, restrictions, and processes as the standard system. That makes some administrators uncomfortable and the natural inclination of large organizations will be to think, "Well this new authority doesn't have this process or rule. We should add that back in as a precaution." And a little while later, another rule or process is added back and then another and another until the new authority is largely encumbered with the same rules and processes you were originally trying to avoid. Resisting these "improvements" requires being constantly on-guard against them, because they each tend to be little things but they add up over time.

Congress's continued support for these authorities and their streamlined implementation is a big help to DARPA.

QUESTIONS SUBMITTED BY MR. ELLSWORTH

Mr. ELLSWORTH. I would like to commend the Department of Defense on the comprehensive report recently delivered to the House and Senate Armed Services Committees addressing the concerns of the National Research Council Committees report on Manufacturing Trends in Printed Circuit Board Technology. DOD suggested establishing Executive Agent oversight by the Navy through NSWC Crane Division for Printed Circuit Board Technology to ensure that the recommended actions are executed so to sustain a robust domestic manufacturing capability. This bold approach should help insure the latest technology be available to trusted U.S. manufacturing who can deliver the warfighter mission critical technologies. This report addresses technology (Research & Development), legacy system support, supply chain management/vulnerabilitics and establishing a competing network of shops that can be trusted to manufacture printed circuit boards for secure defense systems. With many manufactures taking their technologies overseas as a result of the global environment what additional actions are being taken to protect critical needed military technologies and prevent potential defense system vulnerabilities?

Admiral LANDAY. Protection of critical military technologies is being addressed under the Militarily Critical Technologies Program (MCTP) process managed by the Department of Defense, the Arms Control Act (22 USC 2778 and 2794), and International Traffic in Arms Regulations (ITAR) managed by the Department of State and the Defense Production Act (PL 81–774).

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Dr. TETHER. In response to the concerns you note, we began our "TRUST in Integrated Circuits" Program in late 2007. The goal of the program is to ensure the trustworthiness of ICs regardless of where they are designed or manufactured. Of particular concern are the rapid movement of both design and fabrication offshore.

The TRUST program is seeking ways to answer three basic questions about integrated circuits that might be purchased from a variety of places. First, determining if malicious features have been inserted during the design of Application Specific Integrated Circuits (ASIC). Second, determining if malicious features have been inserted during the fabrication of ASICs. And, third, determining if malicious features have been inserted during the loading of Field Programmable Gate Arrays (FPGA). These issues have never been addressed before in a comprehensive manner, and are at the forefront research in this area.

So far we have assembled a strong team of defense contractors, commercial IC designers, small businesses, commercial IC tool developers, leading FPGA vendors and academics all focused on bring innovative solutions to solving the basic issues defined above. These teams have already shown impressive preliminary results to many of the research challenges.

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