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ON

NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2019

AND

OVERSIGHT OF PREVIOUSLY AUTHORIZED PROGRAMS

BEFORE THE

COMMITTEE ON ARMED SERVICES
HOUSE OF REPRESENTATIVES
ONE HUNDRED FIFTEENTH CONGRESS

SECOND SESSION

SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES HEARING

ON

A REVIEW AND ASSESSMENT OF THE FISCAL YEAR 2019 BUDGET REQUEST FOR DEPARTMENT OF DEFENSE SCIENCE AND TECHNOLOGY PROGRAMS

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A REVIEW AND ASSESSMENT OF THE FISCAL YEAR 2019 BUDGET REQUEST FOR DEPARTMENT OF DEFENSE SCIENCE AND TECHNOLOGY PROGRAMS

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES,
Washington, DC, Wednesday, March 14, 2018.

The subcommittee met, pursuant to call, at 3:30 p.m., in room 2118, Rayburn House Office Building, Hon. Elise M. Stefanik (chairwoman of the subcommittee) presiding.

OPENING STATEMENT OF HON. ELISE M. STEFANIK, A REPRESENTATIVE FROM NEW YORK, CHAIRWOMAN, SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

Ms. STEFANIK. The subcommittee will come to order.

Welcome to this important hearing entitled "A Review and Assessment of the Fiscal Year 2019 Budget Request for the Department of Defense Science and Technology Programs."

Defense Secretary Jim Mattis recently testified that, quote: "Our competitive edge has eroded in every domain of warfare: air, land, sea, space, and cyber." End quote. And I couldn't agree more. Our committee, and the Emerging Threats and Capabilities Subcommittee in particular, has spent a considerable amount of time reviewing and understanding adversarial threats, most notably from China and Russia, while also keeping an eye on emerging technology such as quantum science, artificial intelligence [AI], nanotechnology, synthetic biology, autonomy, and robotics.

We have seen troubling adversarial advances in warfighting systems like hypersonics and directed energy, and adversarial advances in enabling technologies, to include high-performance computing and artificial intelligence. We have also learned that many of our adversaries continue to increase their research and development [R&D] budgets, and implement national-level strategic plans.

Russia has increased their basic research budget by nearly 25 percent, and the Chinese have national-level plans for science and technology, as well as an approach to lead the world in AI by 2030.

All of these signs point to top-down government-driven agendas that provide resources and road maps for strategic collaboration between industry, academia, and civil society. These efforts could propel Russia and China to continue to leap ahead in many of the technology sectors we will talk about today.

But adversarial dominance is not a foregone conclusion. What we learn today and in future hearings must be translated into action—to inform and reform the Department of Defense [DOD] in support of national-level efforts in order that the United States remains

home to the world's leading experts, researchers, and technological breakthroughs.

Artificial intelligence is one sweeping area that I am particularly interested in from a national security perspective. Next week, I plan to introduce standalone legislation that will start the discussion on how we should better organize our government to understand and leverage AI.

I look forward to working with my colleagues on the committee, and also with the Department of Defense as we craft solutions for this year's NDAA [National Defense Authorization Act]. Given these challenges, I am very pleased to see a total of $13.7 billion for science and technology [S&T] in the Department of Defense budget request, an approximate $500 million increase, and 2.3 percent of the total defense budget.

But despite this increase, I remain concerned that our S&T investments represent a small percentage of our overall defense budget. To truly increase lethality and provide a superior technological edge for our warfighters, we should ask ourselves if 2.3 percent of the total defense budget is the correct balance. A properly resourced science and technology enterprise in the long run reduces risk, and when properly executed, can generate efficiencies within the Department, something we need to keep in mind amidst debates on sequestration and continuing resolutions.

Now more than ever our S&T enterprise and investments play a strategic role and are central to our national and economic security. This hearing also marks our first open S&T event since the National Defense Authorization Act directed the reestablishment of the position of the Under Secretary of Defense for Research and Engineering [R&E] within the Department.

And as I have said in previous statements, I firmly believe that the Under Secretary for R&E needs to be the prime mover to drive change and foster innovation within the Department. A primary mission of this office should be to provide distinct direction and leadership to energize the defense industrial base, the military services, combatant commanders, and the Department of Defense labs. It must also guide newer initiatives, such as the Strategic Capabilities Office, the Defense Innovation Unit Experimental or DIUx, and even the Algorithmic Warfare Working Group, and the Defense Digital Service.

And while many of these new initiatives have created tremendous momentum and energized the conversation about changing "the culture" of the Department of Defense, much more needs to be done to make these more than one-off quick gains. If properly empowered and resourced, I also believe that the Under Secretary for R&E will be in a unique position to drive a national-level dialogue for S&T policy that will, in addition to helping maintain a battlefield advantage, energize our domestic industrial and innovation bases, and provide technology jobs and opportunities across many of the sectors we will talk about today.

So we have significant expectations, clearly, of Dr. Mike Griffin and his office, but we do so while also offering our support and confidence because the threats we face from our adversaries demand that we energize and organize our government to ensure that policy indeed keeps pace with technology.

So to help us with this important topic today, we welcome five distinguished witnesses, starting with my left: Ms. Mary Miller, Performing the Duties of the Assistant Secretary of Defense for Research and Engineering [USD (R&E)]; Dr. Steven Walker, Director of the Defense Advanced Research Projects Agency, DARPA; Dr. Tom Russell, Deputy Assistant Secretary of the Army for Research and Technology; Rear Admiral David Hahn, Chief of Naval Research; and Mr. Jeff Stanley, Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering.

Welcome to all of our witnesses and we look forward to your testimony. I want to welcome my friend and ranking member, Jim Langevin, whose timing is indeed perfect.

And when he gets situated, I would like to recognize him for any opening comments he would like to make.

Thank you, Jim, I know today has been a busy day for all of us.

[The prepared statement of Ms. Stefanik can be found in the Appendix on page 33.]

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

Mr. LANGEVIN. Thank you, Madam Chair. It worked out well, I actually literally just flew in a little while ago because of the northeaster we received yesterday. I got snowed out and wasn't able to get in until this afternoon.

So, anyway, welcome to our witnesses. Thank you all for being here. And, regrettably, I understand Secretary Griffin was unable to join us today, although I recognize that he was just recently confirmed, and I understand his vision for science and technology and innovation, as the first Under Secretary of Research and Engineering, is paramount for the subcommittee.

And I certainly look forward to engaging him in the very near future. And I appreciate, though, that Ms. Miller is here, that you are here representing the Office of the Secretary of Defense, R&E enterprise, and it is good to see you again.

Today we begin consideration, fiscal year [FY] 2019 budget request for S&T across the Department of Defense, the total is $13.7 billion up from $13.2 billion requested in FY 2018. The amount requested for advanced development and prototyping is $20.8 billion, $3 billion more than requested in FY 2018, for a total of $34.5 billion requested for R&E activities.

This budget request comes on the heels of the recently released National Defense Strategy [NDS] that highlights specific technological advancements that the U.S. needs to leverage to maintain its warfighting edge. Many of these are in areas this subcommittee supported over the years, including artificial intelligence, directed energy, hypersonics, 3–D printing, and autonomous systems.

The NDS also highlights long-term strategic competition with China and Russia and the need for an unparalleled national security innovation base. It is no secret that China is employing measures that encroach upon, poach from, and steal from us to further their objectives to be an R&E powerhouse and degrade our warfighting edge.

This is utterly alarming and greatly affects our national security. Unfortunately, China is not the only nation conducting such activities. They are, however, one of the few state actors that has coupled such tactics with considerable money and other resources behind a national strategy that involves a whole-of-government effort and leverages society to promote indigenous innovation. If the U.S. is to remain a global leader in technology, then we just can't play defense, we must also play offense.

Our efforts to deter and counter China and other actors that threaten our ability to maintain our technological edge are absolutely critical, as are investments in science and research, prototyping, and other development efforts to advance warfighting capabilities and to promote deterrence. No less important are investments in STEAM [science, technology, engineering, the arts, and mathematics] education and in programs that develop junior talent into future tech leaders. And the implementation of strategic policies that promote a sound economic and political environment on U.S. soil where global collaboration, discovery, innovation, public institutions, and industry can thrive.

We must also balance participation in the global S&T and innovation environment with protection of national security interests. Clearly, this cannot be done through DOD alone, however. DOD has a significant role to play as a customer and driver of S&T innovation. DOD S&T ecosystem includes science technology and reinvention laboratories that house some of our Nation's greatest assets and people. It also includes DARPA, which is invested in some of the pie-in-the-sky ideas that came to fruition and change how we fight and how we live.

They have absolutely lived up to what our expectations are to invest in those high-risk, high-payoff initiatives, and avoid technological surprise wherever possible. Over the course of many years, Congress has worked tirelessly to provide authorities and legislation that enable these institutions to be utilized to the fullest potential by the Department. Tools such as the Rapid Innovation Fund and Small Business Innovation Research [SBIR] program have been provided to DOD to leverage commercial innovation and have proven beneficial to that end.

DIUx and other entities have stood up to enable the Department to make use of commercial technology and tech advancements. However, I believe DOD can make better use of these tools as well. DOD also administers the research and education program for historically black colleges and universities and national defense education programs, which I am pleased to say, received funding increases this year, although I believe those increases should be bigger. These programs enhance DOD's S&T efforts and produce top talent for the future workforce.

The NDS framework and the recent reorganization by DOD by Congress to separate program acquisition and sustainment [A&S] from research and engineering provide the Department an opportunity to rethink how it approaches delivering the most advanced capabilities to the warfighter in the near, mid, and long term, and to bridge the "valley of death."

In the era of strategic state competition, it is time to get creative, and we must outsmart our competitors and our adversaries. Today

I look forward to hearing about how the NDS is shaping DOD's R&D landscape; how the budget request reflects an investment being made that serves DOD's interest as both the consumer and driver of technology advancements; and how DOD is leveraging its ecosystem to the fullest extent so that we may remain the global technology leader.

With that, I want to thank you, Madam Chair, for putting this hearing together. And with that, I yield back.

Ms. STEFANIK. Thank you, Jim. We now turn to our witnesses. Thank you for being here today. Your written statements were submitted for the record, so please summarize your opening comments within 5 minutes or less. And I will start with Assistant Secretary Miller. You have 5 minutes.

STATEMENT OF MARY J. MILLER, PERFORMING THE DUTIES OF ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING, OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

Ms. MILLER. Chairwoman Stefanik, Ranking Member Langevin, and distinguished members of this subcommittee, thank you for this opportunity to discuss the state of the Department's science and technology program for fiscal year 2019.

I am proud to be here today representing the newly confirmed Under Secretary of Defense for Research and Engineering, Dr. Mike Griffin, and the scientists and engineers within the DOD S&T enterprise. We are in an era of constant competition. We see nations like China and Russia investing heavily in research, trying to close the technology gap with the U.S. We see high-end military technology that has diffused to many countries that would have been unable to develop it themselves, even reaching some nonstate actors.

In a world with near equal access to technology, speed is becoming the discriminator. Not just speed of discovery, but speed of delivery. How fast we can develop, adopt, or leverage technology to meet the warfighters' needs, and get it into their hands will determine our ability to outpace our adversaries.

Under Dr. Griffin's leadership, I look forward to instilling within the Department a culture that embraces a more agile approach to development and delivery. You have been briefed countless times that our adversaries have spent decades watching us, how we conduct our warfare, how we fight. They have seen our equipment, watched our tactics, techniques, and procedures, and determined our concepts of operations. They have assessed both our strengths and vulnerabilities and strategically invested in capabilities to mitigate our advantages and exploit areas of perceived weakness.

China, for example, has sustained increased defense spending since the early 2000s, with the fundamental goal of dominating the next generation of military and civilian technologies by 2050, making them both a military and an economic superpower that prioritize the research and development in areas that they believe will help them achieve this goal. Areas such as advanced materials and manufacturing, hypersonics weapons, advanced computing, artificial intelligence, and robotics, to name a few.

Similarly, Russia has reemerged on the world stage and is pursuing force modernization while actively seeking to manipulate and dominate the global information environment. Meanwhile, North Korea conducts cyber operations to achieve a range of offensive effects with little or no warning, and continues to flaunt their emerging ballistic missile capabilities on a frequent basis. These threats span the air, land, sea, space, and cyber domains, which have all experienced dramatic capability advancements throughout the world. These advancements, coupled with our adversaries' commitment to a pace of prototyping, experimentation, and fielding that far outstrips our own, present a formidable challenge to our U.S. forces operating around the globe.

In this competitive environment, the Department must pay much more attention to future readiness, and ensure our conventional overmatch remains over time. We must be willing and able to tap into commercial research, recognize its military potential, and develop new capabilities and operational and organizational constructs to employ them faster than our competitors. This would not be possible without our DOD scientists and engineers who are doing groundbreaking and innovative work. They are embracing these hard challenges our military faces every day, seeking to better understand the warfighters' problems and working diligently on affordable and effective solutions.

The Department is addressing critical technology and capability gaps through a combination of adaptation of existing systems, such as efforts conducted through the Strategic Capabilities Office, and the development and introduction of innovative new technologies through our DOD labs and centers, DARPA, and DIUx.

We recognize that our adversaries present us with a challenge of a sophisticated, evolving threat. We are prepared to meet that challenge and restore the technical overmatch of the United States Armed Forces through focus and innovation.

Thank you for your strong interest in, and support of, the Department's science and technology efforts as we work to discover, design, and deliver technology capabilities our warfighters will need now and in the future. I appreciate this opportunity to testify on this important issue, and I look forward to your questions. Thank you.

[The prepared statement of Ms. Miller can be found in the Appendix on page 36.]

Ms. STEFANIK. Thank you. Dr. Walker.

STATEMENT OF DR. STEVEN H. WALKER, DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Dr. WALKER. Can you hear me? Is it on? Okay.

Thank you, Chairwoman Stefanik and Ranking Member Langevin, for having me here today. For 60 years DARPA has held to the singular enduring mission to develop breakthrough technologies and capabilities for national security. The genesis of that mission and of DARPA itself dates back to a commitment that President Eisenhower made that the United States would always be the initiator of strategic surprise.

Working with innovators inside and outside of government, DARPA has repeatedly delivered on that mission, transforming

revolutionary concepts and even seeming impossibilities into practical capabilities for the U.S. and allied warfighter. In the six decades since DARPA was established the world has changed dramatically. These changes include some remarkable and even astonishing scientific and technological advances, that if wisely and purposefully used, have the potential not only to ensure ongoing U.S. military superiority and security, but also to catalyze societal and economic advances.

At the same time, the world is experiencing deeply disturbing geopolitical shifts that pose real threats to U.S. preeminence and stability. These dueling trends of unprecedented opportunity and risk deeply informed DARPA's strategic investments decision moving forward.

My priorities for investment are very much aligned with President Trump's National Security Strategy and with Secretary Mattis' National Defense Strategy. So my priorities for investment in the future are defending the homeland, number one, from varied threats, to include developing cyber-deterrence capabilities, bio-surveillance and bio-protection technologies, and the ability to sense and defend against weapons of mass terror.

Number two. Deterring and prevailing against peer competitors in Europe and Asia will require new thinking. The U.S. can no longer be dominant across all scenarios, but it needs to be highly lethal in select ones. Realizing new capabilities across all the physical domains will be important, and hypersonics will be a key technology there, but we also have to look at space and the electromagnetic spectrum domains. They are going to be very important for that fight.

Number three. Effectively prosecuting stabilization efforts across the globe requires us to get better at fighting differently and in different environments. Capabilities to address gray zone conflict, and 3–D [three-dimensional] city-scale warfare, along with the development of rigorous and reliable models to predict adversarial moves will be critical.

Last, but definitely not least, is number four, foundational research in science and technology. This will underlie all of DARPA's grounded pursuits, and is what makes possible never-before-seen capabilities. We must continue to do what I think DARPA does better than anyone, and that is to follow where technology can lead us to solve the country's toughest challenges.

One of the foundational technology paths we are on currently is to help re-create advanced electronics. DARPA has had a key role over the years in advancing the state of the art in advanced electronics, especially in semiconductors. Today the advanced electronics industry is at an inflection point; design and fabrication [of] semiconductors is becoming ever more difficult and costly.

China, which is significantly behind the U.S. now, has decided to invest huge sums of government-directed private capital to acquire today's onshore semiconductor design and manufacturing capabilities. In 2018, DARPA launched the electronic resurgence initiative, or ERI, which aims to create leap-ahead technology that will develop new materials, new circuit design tools, and new system architectures and manufacturing capabilities for the U.S. semiconductor industry and for our defense sector, to keep us out in front.

As DARPA looks to its next 60 years, it promises to continue to be a bold, risk-tolerant investor in high-impact technologies so the Nation can be the first to develop and adopt the novel capabilities made possible by such work. With the continued support of Congress, and especially this committee, as well as the backing of the Pentagon and my S&T partners on this panel, we will succeed. Thanks.

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

Ms. STEFANIK. Thank you, Dr. Walker.

Dr. Russell.

STATEMENT OF DR. THOMAS P. RUSSELL, DEPUTY ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH AND TECHNOLOGY

Dr. RUSSELL. Chairman Stefanik, Ranking Member Langevin, and distinguished members of the subcommittee, I would like to thank you for the opportunity to discuss the United States Army's program for science and technology for fiscal year 2019. This committee plays a vital role in supporting Army S&T, as the program seeks to ensure the Army can operate and dominate in complex environments.

These environments pose a variety of challenges characterized by adaptive adversaries employing conventional, unconventional, and hybrid methods designed to challenge U.S. national security. The Army and the joint future operational environment will demand a land power dominance with increased flexibility, adaptability, and speed of responsiveness.

As a means to address current capability shortfalls and outpace anticipated threats, the Army S&T strategy pursues a foundational technology development for future, and leverages organic capacity and the capacity of our partners. Army S&T is the only portfolio focused in the Army's future investments. It makes investments today in fundamental science and technology initiatives that will ensure breakthroughs that will yield affordable, decisive, and advantages for the future.

The S&T portfolio is now being rebalanced to meet the Army's needs to prepare for and deter possible near-peer threats in the mid and far term. Based on the Chief of Staff of the Army's guide, the S&T community with our stakeholders, reviewed the entire S&T portfolio and concluded that the existing portfolio was out of balance, with too great of a focus on the near term, and technology developments focused on the counterinsurgency fight versus the near-peer threats.

The Secretary and the Chief of Staff's modernization initiatives have further focused the S&T program on the Army's top priorities, while maintaining vital long-term research into the cutting edges of military relevant science. As a result, greater than a billion dollars in S&T funding was redirected from near-term efforts and projects to mid-term projects, reducing investments in counterinsurgency programs, and increasing and accelerating investments in technologies to prepare for and deter possible near-peer threats.

This portfolio rebalance is impacting budget years 2019 through 2023, which will allow S&T to maintain a balanced portfolio investment to guide breakthrough science and research and technology

innovation. The Army's S&T program fully supports the six key modernization priorities: long range precision fires, next generation combat vehicles, future vertical lift, network/C3I [command, control, communications, and intelligence], air and missile defense, and soldier lethality.

S&T also pursues the broader basic and applied research that will create new capabilities and prevent technological surprise, including, but not limited to eight key technology investments: directed energy, artificial intelligence, robotics, internet of things, virtual reality, energetic materials, and ultra-design materials.

In addition, state-of-the-art technical facilities are essential to ensuring that the Army's S&T enterprise is positioned for discovery and maturation of critical technologies. An enterprise-wide approach to modernize is centered on three primary thrusts: organic technical infrastructure, informing construction of our partner facilities, and infrastructure collaboration such as the ARL [U.S. Army Research Laboratory] open campus business model.

Our S&T strategy provides the unifying framework for Army labs and our industry and academic partners to collaboratively mature new technologies. In addition to the 12,000 scientists and engineers in our S&T enterprise, the Army labs and the research development engineering centers are critical assets for the Army. They have delivered key capabilities and support of ongoing combat operations and will continue to do so in the future.

I welcome your questions.

[The prepared statement of Dr. Russell can be found in the Appendix on page 52.]

Ms. STEFANIK. Thank you, Dr. Russell. Rear Admiral Hahn.

STATEMENT OF RADM DAVID J. HAHN, USN, CHIEF OF NAVAL RESEARCH

Admiral HAHN. Well, good afternoon, and thank you for having me. Chairwoman, Ranking Member, and members of the subcommittee, thank you for your leadership. So the opening comments of the Chair I think provide a pretty good summary of the state of affairs. And I think the significant term there is the advantage has eroded.

Those who have gone before you in the seats that you sit in, in what used to be called the Naval Affairs Committee, back in the year 1946 were going through a similar conversation about how do we sustain science and technology and all that we had learned throughout the conflict of World War II to ensure that we don't repeat those same lessons going forward.

So that group, the Naval Affairs Committee, stood up the Office of Naval Research. And I find the words in the legislation that created the Office of Naval Research continues to provide us our mission statement today. So I think it is important that we think about that for a moment. And I am going to read those words to you because that is what gives us our charge.

So in your legislation, it says that my charge is to plan, foster, and encourage scientific research, in recognition of its paramount importance, as related to the maintenance of future naval power, and the preservation of national security. So those words echo the

theme that as a maritime nation without naval power in the present and in the future, we will find ourselves at a disadvantage.

The National Defense Strategy lays out pretty clearly, I think, that naval power is going to be very important in this great power competition that we find ourselves in yet again. So it is my charge to figure out how naval power is going to get generated through the elements of science and technology.

I think it is pretty clear to the members of the committee that naval power comes from a combination in balance of capacity, capability, and lethality, and science and technology are at the heart of every one of those elements of naval power. Your United States Navy and Marine Corps is going to play the away game every single time.

So my charge is to make sure that we are the first to field to take advantage of the speed of technology that is being created each day and to figure out a way to get that into programs of record where that capability gets to scale, and do it in a more and more lethal and a more and more creative way every single day, leveraging all those pieces of the puzzle that got put together back again in our experience in World War II, and that we leverage going forward to today.

And you mentioned the three legs of that stool: it is academia, it is our industry partners, and it is our government workforce that understands how naval warfighting looks, and what technologies will apply to the naval warfight in the future. And those are the ones we invest in and try to carry forward.

So there is good news here, right? Your leadership and your investment in a continued and steady way across the years has created a workforce of over 4,000 in my part of the enterprise and an analogous number and the same kind of talent across this whole team here. And it is our job to keep that team moving in the same direction, to leverage each other's investments and make the best of it.

So I am happy to take all the questions. I look forward to the dialogue. And I couldn't be more proud than to sit here with the members of my team. Thank you.

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

Ms. STEFANIK. Thank you. Mr. Stanley.

STATEMENT OF JEFFREY H. STANLEY, DEPUTY ASSISTANT SECRETARY OF THE AIR FORCE FOR SCIENCE, TECHNOLOGY AND ENGINEERING

Mr. STANLEY. Chairwoman Stefanik, Ranking Member Langevin, members of the subcommittee and staff, I am pleased to have the opportunity to testify on the Air Force's FY 2019 science and technology program. Challenges and threats to our national security are evolving rapidly. In some cases our near-peer competitors are matching or exceeding our Nation in capabilities.

The Air Force has taken action on multiple fronts to change the way we leverage science and technology. The Secretary of the Air Force recently commissioned a broad-reaching initiative to assess our science and technology investment strategy to ensure our dominance across air, space, and cyber. Because of a variety of factors,

the Defense Department is no longer driving the industrial base like it did 10 or 20 years ago.

The Secretary's initiative is looking across industry, academia, the national laboratories, and other agencies to see where we need to invest in technology, and how we might change our processes and business approach. Change is necessary. And the Air Force is committed to ensuring our warfighters have the best technological advantage we can give them.

Additionally, we have pivoted in several game-changing technology areas to amplify the enduring attributes of air power: speed, range, flexibility, and precision. To do this, the Air Force is partner with our other services and agencies to accelerate the delivery of these technologies. We partner with DARPA on our hypersonics developments and initiated two follow-on developments. We recently completed a directed energy flight plan and are in lockstep with the Navy and the Army to demonstrate mature high-energy lasers, high-powered microwaves for base defense, aircraft self-protection, and other tactical situations.

Attritable systems like the low-cost attritable aircraft technology effort will change future air battles. Teaming with commercial industry, the Air Force has leveraged several advances in additive and 3–D manufacturing technologies, research into limited-life design methodologies, and advanced composites to create a family of vehicles like LCAAT [Low Cost Attritable Aircraft Technology], which are not only lethal but impose costs on our adversaries.

The space industry landscape continues to change and we are aggressively pursuing low-cost access to orbit for payloads and microsatellites with programs like EAGLE [ESPA Augmented GEO Laboratory Experiment], which will launch next month. It is not only the technologies in which the Air Force invests that is important, but the pace at which the Air Force innovates and responds.

Global competition has changed the speed at which the world around us operates. The Air Force recognizes that it is not the country that innovates the best, but rather innovates and applies technology the fastest.

I want to thank the Congress for the recent NDAA language regarding prototyping. Prototyping allows us to bridge the gap between science and technology and programs of record, and deliver capabilities at the speed the warfighter needs.

Lastly, the global competition for technology and the pace of technology development directly translates to the workforce. The workforce for science, technology, and engineering continues to be our most important resource. This is a national issue. And the demand for technical talent is far outpacing degree production in the United States.

We are appreciative of the continued support from Congress through flexible personnel authorities. The Air Force continues to utilize these authorities to ensure we attract and retain the world-class workforce capable of providing these revolutionary capabilities for our warfighters.

In summary, as the Air Force budget request highlights, the Air Force senior leadership is committed to science and technology and driving innovation across our enterprise. I thank the committee for

the opportunity to testify today, and look forward to your questions.

[The prepared statement of Mr. Stanley can be found in the Appendix on page 67.]

Ms. STEFANIK. Thank you, Mr. Stanley. Before we get to questions, I ask unanimous consent that non-subcommittee members be allowed to participate in today's briefing after all the subcommittee members have had any opportunity to ask questions. Is there objection?

Without objection, non-subcommittee members will be recognized at the appropriate time for 5 minutes.

Moving along to questions. As I mentioned in my opening statement, I plan to introduce standalone legislation next week on artificial intelligence, and I understand that the Department is currently working an AI strategy being led by the Under Secretary for R&E's office.

So, Ms. Miller, can you provide this committee with an update on that initiative and are there ways that we can be helpful with this and similar efforts?

Ms. MILLER. Yes, ma'am. So I guess it was last September, we decided that, you know, we needed to start pulling together what everybody was doing in the world of artificial intelligence within the Department of Defense. And we had an opening conference and invited people within the Department that were working in artificial intelligence and some external folks to come in and tell us where they are.

We were surprised by the breadth that this area has expanded because everybody has a way to use artificial intelligence, they can envision it. We started doing weekly meetings with people within the Department of Defense, over 40 organizations, over 150 people, typically, any given week, that come to talk about what they are doing and how they are investing and what their needs are.

Through this effort we have been trying to shape an understanding of what we are spending our resources in and then to try to organize those efforts into something that would apply to the National Defense Strategy, and where we need to go. You have to understand what people are doing and then figure out how you need to shape it into the end state of what the Department needs.

So we have got five aspects that we are looking—five goals that we are looking at. One is foundational. We need to establish a workforce that is—understanding artificial intelligence. We need to complete partnerships. We need to understand and acquire data so you can actually train your intelligent agent. We need to develop standards and the policy to be able to use artificial intelligence, in many of the ways that the Department would need.

Our second goal is to be able to attain technical superiority. So, the foundations of what AI is. Machine learning that we are working on. Data analytics. Robotics. Advanced computing that allows us to exercise artificial intelligence. And how humans and AI can work together to give better capabilities to the warfighter.

We have looked at how we can apply third goal. How we apply AI to business functions. Because the Secretary of Defense has made business reform his number three priority in the Department. The more we can save through our business reform, the

more we can spend on achieving and attaining that lethality that he desires for the Department of Defense. So we are looking at how do you apply AI to not only training and education, but finances, the medical field, and what we do in contracts, acquisition, and legal activities.

And looking at affected intelligence analysis. You have heard about Project Maven, that is clearly kind of our set of how data analytics and artificial intelligence can better inform a warfighter. So we have this whole intel [intelligence] side of this as well. And ultimately we are trying to get to lethality, and that is where we take artificial intelligence and applying it to what we are doing in command and control and communications and survivability in the breadth of what the Department is doing.

Ms. STEFANIK. I want to give the other witnesses an opportunity to answer questions as well on this topic. Dr. Walker, can you—thank you. Ms. Miller.

Ms. MILLER. Uh-huh.

Ms. STEFANIK. Dr. Walker, can you discuss your AI efforts within DARPA, and then understanding we are in an unclassified forum, are there any adversarial concerns regarding AI that are on your radar that you can share with us today?

Dr. WALKER. Sure. DARPA has been involved in AI since 1960, when we wrote the first—our information office director wrote the first paper, Man-Computer Symbiosis, so we have had a hand in much of the development along the way. We are really focused now, much of the commercial sector is applying what we call machine learning, which is sort of what we look at as second-generation AI.

What we are focused on now is third generation, and that is, you know, machine learning requires, you know, large data sets, you train—it really should be called machine training. You are training a machine over a large data set to recognize patterns, et cetera. What we are focused on is third-generation AI where you are—and the environment is changing, and so the data set is changing, and how does the machine react to that? Can it still give you a good answer? And so we have a program called Explainable AI that is not just spitting out an answer with a probability of correctness, but actually looking at—the machine gives you an answer and it tells you how it got to that answer, why it came up with that answer. That is one example of a program in our third-generation effort.

Another one is lifelong learning for machines. And so when a piece of data changes, the environment changes, how does the machine respond to that and how does it get back up on a correct answer? In terms of your second part of your question, what is the adversary doing, it is well known that adversaries, as well as others, are able to manipulate images and videos using AI techniques.

We have a program called Metaphor, which is looking at applying AI techniques to understand when images, when videos have been tampered with, to provide some truth-telling in that scenario.

Ms. STEFANIK. Thank you. Mr. Langevin.

Mr. LANGEVIN. Thank you, Madam Chairwoman. I certainly look forward to cosponsoring the legislation that you are introducing. And, you know, I also hope we are—we talk about standards that

we are also proceeding with well-thought-out caution as well that we understand where this is going and doesn't get too far ahead of us that we can't control it, as we saw recently with the experiment that got shut down with the Facebook AI talking to each other, and started talking to each other in a language that we didn't know what it was. And they had to shut it down. And, again, understanding where this is going and proceeding, we both, you know, trying to innovate as much as possible, but also make sure it doesn't get away from us.

I am going to switch over to another area, just more broadly to all witnesses. How has the National Defense Strategy shaped how we think about RDT&E [research, development, test and evaluation], and how does the fiscal year 2019 budget request reflect a new approach that is different from the third offset strategy developed in the DOD under former Secretary of Defense Ash Carter. And what is the status of long-range research and development planning activities?

I want to start with Ms. Miller.

Ms. MILLER. So I would tell that you the National Defense Strategy, we were part of the development of that and had a lot of discussions primarily on where the Department needs to go to modernize, and what we needed to think in that area. We have started to resonate and it can't be just about systems anymore, it needs to be about missions that have to be accomplished. And in that context, when you look at what is out there today and what needs to be out there in the future to accomplish the mission, that is where you start to see science and technology play a larger role, and you will start to see investments that will be mission oriented to give us options. The Secretary of Defense has asked for many options to prosecute these missions, and that is what we will bring forward.

Regarding the long-range research and development program plan, we intended all along to do this on a quadrennial basis to get people together, to think outside of the box, and to not be constrained by how we currently fight. And we do intend to do that, it will probably be 3 years from now.

Mr. LANGEVIN. Thank you.

Dr. WALKER. All right. To follow on to Ms. Miller, for me, DARPA is looking at the NDS very closely, especially in the area of lethality, and applying—trying to think through how to deter and prevail our peer competitors in key areas of the globe. One of the areas that we have been working in and will continue in a bigger way to work is hypersonics, to enable that greater lethality. We are working with our partners to do that, and I hope to talk a little more about that, but I want to give them a chance.

Dr. RUSSELL. So the question was also about the long-range research development planning. I think you will see in the Army S&T program it has really been rebalanced to look towards a near-peer threat, and it is really a threat-based approach, looking at what are the challenges we face in a land battle. And the focus has been driven towards six modernization priorities. And the six modernization priorities were designed around the ideas of the fundamental functions of warfighting on land, which is how do I move, shoot, communicate, and protect.

And in those areas there are applications or science technology programs which are looking at, how do I extend the range of artillery, how do I extend the missile range so that we can actually have a longer range precision fires, and as well as a multidomain, so looking at land-based anti-ship missiles. In the defensive area, we are all working areas of high-energy lasers and so there is some activities looking at mobile SHORAD, which is short range air defense, as well as high-energy lasers for tactical vehicle demonstrators for IFPC [Indirect Fire Protection Capability] Block 2. I just want to end there and give my colleagues a chance to answer as well.

Admiral HAHN. Gentleman, Mr. Langevin, thank you for the question. The National Defense Strategy brings into pretty sharp focus for us that we are in a high-end fight, that is where we need to focus the efforts of our technology implementation onboard our platforms. It also puts a premium on speed. So I associate myself with all the remarks that you heard about this topic so far, but it is the speed of moving that technology at scale to the platform so we get it in the hands of the sailors or Marines or the airmen. That is what this National Defense Strategy has done. It juiced this whole process. We are thinking differently about how we create pathways to move this technology through the snake, if you will, to get it all the way to the end point.

So that is what has got us thinking hard every day and looking for new opportunities. And I would just close with the fact that instead of being a, let's go manage risk, this is more of an opportunity-based focus. Let's find the opportunities. Let's figure out how we take them, put them into evidence, and create that deterrence so that when they look at us, they understand, here is what you are up against.

Thank you.

Mr. STANLEY. Sir, I just amplify what Admiral Hahn just talked about is the speed. The NDS is clear on the use of experimentation prototyping and advocating for that. And I think in the Air Force we have wholly embraced prototyping as a way to speed delivery to the warfighter, and I think that is going to be key in the future.

Mr. LANGEVIN. Thank you. And hopefully we will go to a second round.

Ms. STEFANIK. Ms. Cheney.

Ms. CHENEY. Thank you, Madam Chairwoman, and thank all the witnesses for being here today.

Dr. Walker, I wanted to ask you, you mentioned in both your written testimony, and here today that we are no longer dominant, I think you used the phrase, "across all scenarios." And I wondered if you can elaborate on that a little bit, and talk specifically about, have decisions been made that we won't attempt to achieve dominance, that we determine that there are certain areas where we simply are going to accept a lack of dominance, accept being second to someone else.

Dr. WALKER. I think what I meant by that was—really in the context of lethality trying to think through new warfighting constructs that would allow us to really be more effective, to have multiple constructs that we can set up against our adversaries so that they are surprised, they are not anticipating the next fighter air-

craft or the next tank they know that we are building. But we are putting systems together in new ways that will surprise them in the end. And so trying to think through not the next system, as Mary said, not developing necessarily the next system, but develop—focus on the mission and understand how we can put multiple systems together in different ways and surprise the adversary.

Ms. CHENEY. Maybe we will have an opportunity to follow up in a closed setting about that particular issue.

Dr. WALKER. Sure.

Ms. CHENEY. And in particular areas where we may now decide that we are going to seek dominance.

And in my second question, I am not quite sure to whom I should direct this, but it is about hypersonics and the extent to which our obligations under the INF [Intermediate-Range Nuclear Forces] Treaty are having an impact as we are looking at design, as we are looking at testing.

To what extent are those imposing restrictions on our testing of that system could—I am not sure whose question that is.

Dr. WALKER. I think we are certainly conscious of the INF Treaty. We are developing hypersonic systems that would be compliant with that.

Ms. CHENEY. And so I guess the converse of that would be if we were no longer the sole nation guided by, bound by the INF Treaty, we would have a wider range of testing, we might be interested in doing with respect, and able to do with respect to hypersonics?

Dr. WALKER. That is fair.

Ms. CHENEY. Okay. Thank you very much. I yield back.

Ms. STEFANIK. Mr. Larsen.

Mr. LARSEN. Thank you, Madam Chair. Ms. Miller, the budget for science and technology represents about 2.3 percent of the total budget, is that about right?

Ms. MILLER. Yes.

Mr. LARSEN. Is that enough? You have to answer more quickly than that, I only have 5 minutes.

Ms. MILLER. I will tell you that, yes, we could do with more. Right now you have an increasing top line, thanks to the administration.

Mr. LARSEN. Right.

Ms. MILLER. Looking favorably on the Department of Defense. The majority of that money did not go into the science and technology, it went into getting us whole for readiness, and that was the priority. As we invest in science and technology, we need to have the money to take it out of science and technology into programs of record, and we have been having that conflict of maintaining a ready force and being able to pull technology into new systems.

Mr. LARSEN. And I understand Secretary Mattis' concerns on readiness and the O&M [operations and maintenance], but it seems that we have been ringing the bell a little bit, and we've heard about it here today about the investments our competitors are making. And yet, I know there is more money in some parts of the science and technology budgets, but not in all parts. And I think there is a percentage that it may be lower than it was in the 2000s

when I first came here. I have got to double check that number, it is a long time ago, and my memory is getting bad, but it might be lower as a percentage.

So I guess I just want to—if we are truly concerned about this, it seems, since we have lifted the top lines, that science and technology needs to have a higher priority at the Department than it is getting.

Ms. MILLER. I would say the fact that we have an Under Secretary for Research and Engineering who is 3 weeks and 1 day in the job, as we build the next budget, you will certainly see his influence.

Mr. LARSEN. I will make a note of that.

Admiral Hahn, can you talk about the impetus for the establishment of the Robotarium at Georgia Tech?

Admiral HAHN. You have that right, the Robotarium.

Mr. LARSEN. Okay.

Admiral HAHN. So, clearly, if we can provide an opportunity, a sandbox, if you will, where we can get vehicles in a setting where they can be operated safely by a number of—a number of folks remotely who may be coming from different spots in the United States, either locally or all the way across CONUS [contiguous United States], to be able to iterate our way through the use of robotics in a variety of scenarios across a number of domains, we are going to learn faster. So the Robotarium investment created that ecosystem, if you will.

Mr. LARSEN. That is at Georgia Tech, and that is—so is it just ONR [Office of Naval Research] money, or is it university money?

Admiral HAHN. Now, there is some National Science Foundation money there as well. Other contributions are invested in there, and it is probably not the only place we should be doing that, frankly, because this is an area where we get the smart people really helping us iterate our way through how are we going to work through this manned, unmanned teaming? How do we get vehicles working together? So any opportunity to make that a more prevalent sort of a sandbox approach in other places is certainly welcome.

Mr. LARSEN. Yeah, it is something that has interested me, so I'm glad to hear you are interested in maybe replicating the concept or growing the concept, and it is worth exploring.

Dr. Walker, as far as DARPA's—not your specific plans, but are you still—do you still see yourselves as the 10- to 30-year look part of our research team in the Department of Defense?

Dr. WALKER. Yes, we do.

Mr. LARSEN. Longer term.

Dr. WALKER. Yes, we do.

Mr. LARSEN. And do you feel that you can take enough risk in order to make mistakes in order to be successful on a long-term look, or do you feel pulled back at all?

Dr. WALKER. No, I do feel like we have a risk-tolerant culture, we don't set out to fail, but we do fail along the way. And we know we are having impact when we do because we are reaching.

Mr. LARSEN. Uh-huh. Yeah. And I think that is enough for me. That's great. Appreciate it. Thank you.

Ms. STEFANIK. Mr. Lamborn.

Mr. LAMBORN. Thank you. Thank you all for what you are doing.

Ms. Miller, I have a question for you first. Last year I worked on the provision that would allow the new IP [internet protocol] office to address IP data rights on SBIR transitions, including serving as a liaison between DOD and SBIR companies when IP issues arise.

Could I please have an update on how we are implementing this provision?

Ms. MILLER. Sadly, I will have to take that for the record. The SBIR office will become part of the USD(R&E), it currently has not been attached to that. It belonged to the small business office, and so I don't have that information with me.

[The information referred to can be found in the Appendix on page 89.]

Mr. LAMBORN. Okay. Then please take that for the record. And hopefully you can answer this part as well. I am also interested in your implementation of NDAA section 1710, which started a pilot program to streamline the commercialization of SBIR and STTR [Small Business Technology Transfer program] products and services, including encouraging a multiple award contract for these products and services. Can you give me an update on that?

Ms. MILLER. Again, I will have to take that for the record, sir. I am not prepared to discuss it.

[The information referred to can be found in the Appendix on page 89.]

Mr. LAMBORN. Okay. I will look forward to that and thank you for offering to do that.

And then, Dr. Walker and Mr. Stanley, I have a question on space situational awareness and battle management command and control. What is being done to fix these two things, these two important issues, and how quickly will we close the gaps?

Dr. WALKER. Well, sir, on battle management command and control, we are about to start a new program called Black Jack, which is looking at developing a large constellation of LEO [low Earth orbit] satellites that will provide the ability to command and control, ISR [intelligence, surveillance, and reconnaissance], and other missions. We are going to do this by leveraging the commercial sector and plugging into what they are doing.

And so this program is starting—it is starting with the Air Force. AFRL [Air Force Research Laboratory] is a full partner, and the Air Force Space Command is very interested in the concept for trying to integrate space and the tactical warfight in a much bigger way than we do today.

Mr. LAMBORN. That is good to hear.

Mr. STANLEY. Sir, as you know, space has become a very contested territory for us. We have set priorities in our investment in building a resilient multilayer space architecture. One of the prototyping programs we are doing right now is called Global Lightning, which is utilizing commercial satellites to do our space situational awareness and communication structure. It is a prototyping program right now to demonstrate the feasibility. Those are the kinds of efforts we have underway to build that resilient architecture we will need in the future.

Mr. LAMBORN. That is really great to hear. I am glad that you all are working diligently on that and I appreciate it. And I will

take some answers from you on the record when you are able to get back to us, and I appreciate it.

I yield back the balance of my time.

Ms. STEFANIK. Mr. Veasey.

Mr. VEASEY. Thank you, Madam Chair.

I wanted to ask specifically about some of the technologies that you are concerned about that our adversaries may have and how you feel that we are being able to, I guess, rise to the challenge of being able to bring us up to speed technological-wise on some of our systems.

I know, for instance, that there has been a lot of discussion and talk out there that the Chinese and Russians, that they are able to get certain systems up and going while we are still sort of working on things and still going through the technology aspects of that. I didn't know if you had any sort of insight on that at all?

Yes.

Dr. WALKER. Sir, the one technology that keeps coming up in my mind that I get concerned about is biology just because of the—I mean, there are several reasons, but the fast pace of tech development in that field. We at DARPA started a biological technologies office about 4 years ago because of this very issue. One of our core missions is to prevent technological surprise, and so we want to be ahead of the game. So we have, just as an example, a program called Safe Genes, which is looking at understanding how gene editing actually works and then developing capabilities to reverse it as well as prevent it from occurring in the wild if we need to because our adversaries have done something.

And so this is a program. It is an unclassified program. It is a basic research program at this point. But, again, it is DARPA trying to understand the technology so that we are not surprised by it.

Admiral HAHN. If I could just pile onto that real quick, sir. It is not any specific technology that causes me concern, because every technology that we are interested in, China is interested in. They leverage much of our basic research, everything that is done out in the open. What bothers me more are the lack of structural impediments that they have to move those technologies from a university setting or a commercial setting into a military application. There are no structural impediments. In fact, they have lubricated that system to a point where, if there is direction to move it, it goes.

We don't enjoy that same kind of streamlined system by design. I am not saying we need to change our design in that manner the way China has, but we certainly do need to think through structurally how are we going to do this differently so that the great work that is done in sort of the S&T side of the business and that we see every single day in our personal lives, when it comes time to apply it to naval warfighting or the rest of the fight, the joint fight, we have got good pathways to get it there. So that is the part that worries me is our ability or inability to move at speed.

Mr. VEASEY. When it comes to creativity, how are they doing on that? Because I know in the past that has always, you know, been an issue with China is that, yes, they are able to produce technologies and they are able to copy technologies. But as far as creativity is concerned, sometimes they lack in that area.

Are you starting to see them catch up in the area of creativity?

Admiral HAHN. The short answer is yes. So the creativity factor is there. It is not lost on me that the same places that educate many of their scientists and researchers are, in fact, the places here in the United States that educate ours. Their sophistication about military applications, the CONOPS, or the concepts of operations that those would fit into are not that much different from ours. So this notion in the National Defense Strategy to start to create dilemmas, create surprises like Dr. Walker indicated, that is becoming more and more important as we consider the use of technology and how we apply it and put it in evidence every single day.

Mr. VEASEY. Thank you.

Dr. Russell, did you have anything?

Dr. RUSSELL. I guess I will just add on the—where they are just copying what we are doing. I think in the area of quantum there are some areas where you can see that they—the Chinese, in particular, have actually been able to do satellite communications. But we have not done that in this country, which is a step beyond where we are at today. So it is not purely that some of our near-peer adversaries are just mimicking or replicating the work that we are doing today, but they are beginning to lead in several of these areas. And I think it is—part of it is driven by what Admiral Hahn mentioned, is there is a lack of barriers to be able to transition and move technologies that we face here in this country today.

Mr. VEASEY. Thank you.

I yield back, Madam Chair. Thank you.

Ms. STEFANIK. Mr. Knight.

Mr. KNIGHT. Thank you, Madam Chairman. Thank you for allowing me to ask a couple questions. I am not on this committee. But any time Dr. Walker is in the room, I want to come in and chat about hypersonics.

So my first questions, Mr. Larsen put a couple words out there that I think we should all be very aware of, and that is risk tolerance. I think that what we have done over the last maybe 30 years has gone into a society that we don't want to take risk. Unless it is perfectly ready to go, we don't do it.

So my question is about some of these more advanced projects that we are working on, like hypersonics, which we have been doing for 60-plus years, but we are now calling them advanced, and X-Plane programs that we have kind of let go beyond the last couple decades, and now we are trying to revamp them. And I know NASA [National Aeronautics and Space Administration] has got their New Horizons projects.

But let me ask the panel: Where you do stand on X-Planes? Where do you stand on kind of prototyping and getting something from a prototype to an action, to a weapon or an airplane or something very quick and that might take some risk also?

Ms. MILLER. So I will start and say in the 3 weeks 1 day that my boss has been on the job, he has certainly made it clear that he embraces the authorities that are given to him to do prototyping and experimentation and to do it with a purpose. When he was in his confirmation hearing, he talked about the major prototyping efforts that used to happen in the past and how we learned so much

from those and how they did, in fact, give us capability that we could operationalize very quickly.

I anticipate that we will see more of that as we all embrace the use of prototyping to help speed capability to the warfighter to make sure we get it right.

Mr. STANLEY. Sir, as you well know, the Air Force was built on prototyping. And we are getting back to our roots right now. As you mentioned, the two hypersonic prototyping programs as a follow-on to our partnership at DARPA right now. In addition to those, we have a low-cost attritable aircraft program that is a prototype out there.

We had the Spectral Halo program, Global Lightning program. And what has made us be able to do this in the past couple years is, first, the section 804 language that increased the prototyping mind-set. And then, secondly, we have got a BA4 line specifically set aside for Air Force prototyping that we have really leveraged. And based on our new warfighting construct, we have tried to allow that line to be our exploration line to see the art of the possible.

Mr. KNIGHT. Let me follow that up real quick.

Do we screw it up here in Congress? Because we get projects out there like the Airborne Laser or some project like that that shows great promise and shows great action, and then funding is cut on a program that was about $12 million, or something happens that we don't take that to the next step and say this is something that we can absolutely use in the future.

I just worry about, every time we stop a project, that data stops right there. And then when we pick it up a decade later, we have to pick up data that is already a decade old. And other countries can pick up that data, whether it be hypersonics or lasers, or whatever we are talking about, use that data or steal that data, which many countries are good at that. And then they are three steps ahead because they have used our three steps of R&D to get them to maybe operation.

So, you know, these are blanket statements, but I think everyone understands where I am trying to go with this. Congress needs to be good at saying, "Go do this. We are going to fund it. Make sure it works, and keep going." Because whatever it is, I could pick 20 projects out of my head right now that have gone to a data collecting position and never to the next step.

So I will leave you with my last 22 seconds.

Hypersonics. Are we moving fast, Dr. Walker.

Dr. WALKER. We are. We are about to, I should say. The new budget has given us a lot more money in the Air Force to basically take what we have been doing and what we are going to fly next year and prototype it into operations.

So I am excited by the new budget and the ability to do that. The services are looking at hypersonics and looking at incorporating that into a new construct for fighting wars in the Pacific and elsewhere. And I think we will be moving out, especially, as Mary said, under the new USD (R&E), who is an aerospace engineer and has stated publicly that hypersonics is his number one priority.

Mr. KNIGHT. Thank you, Madam Chair. Thank you.

Ms. STEFANIK. Thanks.

You'll have to take the rest for the record.

We have time for the second round of questions. Votes have been delayed a bit, and I know members have additional questions.

My question, Mr. Stanley, you mentioned additive manufacturing in your opening statement, and that is a technology that is of particular interest in my district. And it is an increasingly important transformative capability for the Department, especially as we are able to use critical materials titanium and other metals.

So first I want to ask Ms. Miller what is the Department's approach to additive manufacturing? What is being done to support the adoption of these capabilities?

Ms. MILLER. Well, we have a national manufacturing institute that was focused on additive manufacturing America makes, and that was started in—I think it was in 2012. You know, the national manufacturing institutes were set up for 5 years of government funding, and then they were meant to be self-sustaining.

In that particular effort, Mr. Stanley might be able to follow on, because the Air Force did pick up and add resources to them, because we are finding great benefit of that particular manufacturing institute. Additive manufacturing, as all the services will tell you, has been something that is part of our discovery of how it can benefit across the many disciplines that we have.

Ms. STEFANIK. And before I turn to Mr. Stanley, who I am going to follow up with, are there ways for the Department to validate or ensure that the manufacturing processes are uniform to guarantee trust, inflate safety, or other critical parts?

Ms. MILLER. That is an effort that the services are deliberately making to understand that if we can 3–D print something, but we need to know that every time we print it, it is going to be the same and have the right attributes. I know I personally was at AFRL last year and saw them working on how they do it that. It is an area of research. And, yes, we need to do it.

Ms. STEFANIK. Mr. Stanley.

Mr. STANLEY. Ma'am, additive manufacturing is a key fundamental building block for our systems going forward, as you have quite eloquently talked about. In addition, we are putting a lot of resources behind that certification process of these additive manufacturing designs and products that we are spitting out.

So that is an important piece. We have got to come to agreement amongst the services, amongst the other agencies, the FAA [Federal Aviation Administration] included, on how we certify additive manufacturing parts for airworthiness and flight safety.

Ms. STEFANIK. Do the other services want to add here?

Admiral HAHN. Certainly do.

So inside the Navy, we are taking an all-the-above kind of strategy to work additive and advanced manufacturing mechanisms where they make sense. So if we can push a 3–D printer out to the edge and have a sailor or Marine print a part that is appropriate to relieve a logistic supply problem, that is great. But the hardest thing is going to be to get to airworthiness or, near and dear to my heart, something that I would put on a submarine and take that ship down to test depth and depend on that.

And at the science level of this, we need to understand what is happening at the microstructure when we now take that same material that we know exactly what happens, or pretty well what hap-

pens, when we forge it or we cast it. But now we create a little molten pool at the micro level and create a part for it. That is much, much different. So that is significant research that needs to be done. We are doing it together, which is the good news. And we are doing it nationally, which is the better news. And once we get that, then we unlock the design space, because once you capture that digitally, then you can understand how now I can remove weight from that part, I can get the exact attributes I am after, and I can manufacture it differently, cheaper, with more fidelity, more repeatability using these advanced manufacturing techniques. So it will unlock quite a bit, and we need to get an advantage there and then keep it.

Ms. STEFANIK. Dr. Russell.

Dr. RUSSELL. Yeah, I agree with most of my colleagues—with all my colleagues. One thing I might add to it, it gives us the ability to be more adaptive to the threat. So as an example, we have a program currently in the Army. Instead of making small UASes [unmanned aerial systems], instead of producing 700 UASes, what you might do is produce different capabilities and then have the ability in theater to produce a smaller UAS capability that would adapt to the threat that you are actually seeing. So instead of going to an industry and say, well, we need 400 or 700 UASes to support the mission, you actually produce them in real time and be an adaptable to the threats that you are seeing.

Ms. STEFANIK. Ms. Miller, one more follow-up.

You mentioned the national manufacturing institute. How are you leveraging the private sector research and the innovation that is happening in additive manufacturing?

Ms. MILLER. Well, through that particular institute, we do have—you know, it was kind of—the national manufacturing institutes are almost a pilot for that private-Federal partnership, and it has been very effective. We have, I think, over 45 industries that are part of that consortium in working with the government and trying to create that national capability. So I think we are leveraging them fairly effectively in that particular space, and actually the rest of the institutes as well.

Ms. STEFANIK. Thank you.

Mr. Langevin.

Mr. LANGEVIN. Thank you, Madam Chair.

Again, thanks to our witnesses.

Admiral Hahn, let me go back to something you said, I found it interesting, in that you talk about China's agility, that they don't have the same kind of limitations that we have because of the structure that exists. Not to replicate what they have, but how can we make our system more agile? Especially when you are talking about technology, it seems like those types of limitations really, on us now, very—have us proceeding with our hands tied behind our back if we can't move with the kind of agility that needs to be when it comes to technological advance.

Admiral HAHN. So this is the 64 million or billion or trillion dollar question, I think. And it goes back to, I think, a little bit of Mr. Knight's thread as he kind of walked through the question, are we messing this up. And not that the Congress is messing it up, that we are together, I think, messing this up, in that we don't recog-

nize the continuum of activity that must occur to pull one of these things through. We are going to fail sometimes, which needs to be okay. Because I failed doesn't mean that the funding is going to go away. Because I failed doesn't mean that we are going to stop the project. We got to continue on.

We are going to move through different levels of expertise and different phases of this as we move ahead. And many times when that happens, at least inside of the services, we change the people who are involved. And the expertise goes from, oh, that is the science part. Now it is into the engineering part. Well, not really. It is all a blend, right? And more and more as we find these threads that we need to pull, we need to maintain our focus on it.

So I am particularly encouraged with some of the things that I see happening in the Navy. The CNO [Chief of Naval Operations] and the Secretary [of the Navy] as well as the new ASN(RDA) [Assistant Secretary of the Navy for Research, Development, and Acquisition], Mr. Geurts, have put a laser focus on some of these things that are important to bringing some lethality and some of this technology into the fleet and force. One of those areas is directed energy with our Navy family of lasers.

And in and amongst that, we are taking more than one approach. We are not putting all our chips into that technical approach. We have three or four involved with that. We recognize that we are going to learn as we go. We have broken the problem into pieces so that a state of the practice fiber laser is being used to integrate onto a DDG–51, a destroyer combat system. That is a hard problem in and of itself. If I combine a state-of-the-art laser, then I am doubling or tripling my problem.

So we are thinking through ways that we can divide the problem, but keep the focus and set up a series of, if you will, frog races, where these things are going to bump along at the pace that technology moves. Some may be better than others. But at the end point, as soon as it is ready, we want to have figured out the way to get it onto the ship, the plane, or the submarine, or in the hands of that Marine and not have the funding fall apart as we go through.

So I applaud the Air Force for their dedication to this BA4 activity that they protect as sacred to prototype and figure out a way to get that stuff fielded.

So that is the right answer. And, you know, we are trying to replicate that. We require your advocacy and help to keep those things going, because a lot of times it is the certainty and the continuum of funding across this set of activities that becomes the impediment.

Thank you.

Mr. LANGEVIN. Thanks for the answer, Admiral. And I think we have to have this philosophy that it is okay to fail as long as there is good lines of communication between the R&D community and the Congress, we can take these leaps together. And as long as we are not failing, then the—I like the Elon Musk philosophy with his people that if they are not failing, they are not trying hard enough. And we need to be okay with failing sometimes as long as we are doing it the right way and there is good communication.

Let me just—it is kind of a related point. Ms. Miller, as I stated in my opening statement, I believe the reorganization provides an opportunity to rethink how DOD delivers most advanced capabilities to the warfighter in the near, mid, and long term. So related to all of this, for instance, it provides an opportunity for the Department to bridge the "valley of death," so—that so many technologies and companies fall victim to, as well as provide an opportunity for greater leveraging of the DOD S&T ecosystem like labs.

Can you please describe how R&E will work with the acquisition and sustainment side of the Department and how DOD's S&T ecosystem is being leveraged to its greatest potential?

Ms. MILLER. Yes, sir.

With regards to the R&E and the A&S partnership, and it does remain a partnership by necessity, the USD(R&E) was given the authority to take that risk, to move fast, to fail and learn and try and use prototyping and experimentation to better inform, one, what the technology risk is and to drive it down where we can, and to inform requirements.

Because as you well know, acquisition is based on the requirements and getting those requirements right. And one of the things that all of the services I think would agree with me when I say, sometimes we get requirements that were given to acquisition that aren't really what the warfighter wants. And the experimentation venues that the Under Secretary was given, the ability to do prototyping experimentation or helping to refine that before we get launched.

So we will do those risky things and try to drive down risk and inform the requirements before we launch formalized programs of record. And then we go into those programs of record, and we have a better chance of success. The partnership is there. We need the acquisition guides to be the sounding board for when we are really crazy and we can't get the program there. And we need to be the guys always telling acquisition you have got to take it to get that next step beyond where you are. Don't just settle for an incremental change. And I think you are going to see that.

Mr. LANGEVIN. Good. Very good. Thank you.

I yield back.

Ms. STEFANIK. Mr. Larsen, do you have additional questions?

Mr. LARSEN. Thank you.

First, Ms. Miller, I apologize. I did not see that you are a Washington Husky. But I am glad you are, so—yeah. And on that point, my other son—my one son is there. The other son is actually in the engineering school at a different school. But it brings up the point about the workforce and the STEM [science, technology, engineering, mathematics] workforce the pipeline create. And some universities, including "the W" [University of Washington] now have changed. They haven't changed the requirements so much to get into engineering, but a lot of the larger state schools—you got to apply to the school, get in the school, and then, while you are there, get the grades to apply into the engineering school or the business school or so on.

And some of the larger schools are changing that because, for whatever reason, it is providing them more opportunity for domestic students to get into these schools.

And so this really gets into the question about the availability of the pipeline, the availability of the workforce, if it is necessary to have U.S. citizens or not, and what that means for you in terms of recruiting for the workforce that you need to continue to do the work that you are doing. So it is all kind of related, but I just wanted to—it is really about that availability and what things can you do to open up that pipeline. And have you thought through that?

Ms. MILLER. We have been thinking through it. It is a concern for all of us because a STEM-literate citizenry is not only important to the Department of Defense, it is important to the Nation writ large. And so, actually, the services and OSD [Office of the Secretary of Defense] and the defense industrial base have been doing what they can to incentivize this STEM pipeline, as you put it. All of the services reach down into the early grades on up to get that resonance of wanting to be in STEM.

What we have been trying to do is champion additional incentives to keep U.S. citizens working into the higher academia, like Ph.D. programs, so that they will work in areas of national defense. This is an area where, in many disciplines, we get foreign nationals that will be doing that work and doing that Ph.D. thesis. And the U.S. citizens are going out and getting jobs. And it does not help us when we see reports where, gee, you can get out with a bachelor's and start to work right away, and you can make more money than somebody who can get a Ph.D. and took 7 years to get there. That is not helpful to us.

However, it is up to us to one, we give them good problems to solve in the Department of Defense, because we have very challenging problems. But we need to help them make sure that that is the choice that they want to make. So we are offering scholarships to help incentivize them to go into discipline areas that will help us. And we are looking at how we can make it more enticing to keep them in that.

Mr. LARSEN. Yeah. Are you exploring at all the ability—you have a flexibility to bring people in and out. So on the National Guard side, you got cyber warriors, you know, folks who can give you a weekend a month and 2 weeks a year, and you can bring them in, you can bring them out when you need them, as opposed to making them commit to wear the uniform for 3 years.

Ms. MILLER. Yes. We are absolutely looking at the flexibilities of being able to bring people from academia, industry into the government and send them back out again.

Sadly, if you are a government employee, when you go out, you sometimes have limitations. And there have been—some of the language that had been provided is being interpreted in a way that folks don't have the flexibility to come in and out and not be held—I guess prevented from working in that discipline. And that is something we are working on. How do we make sure that we do not disadvantage people that want to come work in the Department.

But the way the world is right now, people want to change jobs frequently. They want the experience. And we want to maximize our ability to do that.

Mr. LARSEN. Yeah. That is fine.

Thank you. I yield back. Go, Dogs.

Ms. STEFANIK. That is it for our questions. And in closing, I want to thank the witnesses. I want to thank the members, both the subcommittee members and the non-subcommittee members, for their excellent questions.

And I want to reiterate the quote that I included in my opening statement from Jim Mattis, who recently testified. Quote, "Our competitive edge has eroded in every domain of warfare: air, land, sea, space, and cyber."

From my perspective, it is our responsibility as policymakers and as a Congress to ensure that we don't lose a competitive edge in any domain or in any technology, particularly as we look at what 21st century warfare looks like in the next 10, 20, 30 years.

And I also wanted to reiterate Dr. Walker's comment where he stated one of the founding missions of DARPA was to ensure that the U.S. is always the initiator of strategic surprise. That is something that we need to continue to focus on as policymakers when it comes to our S&T portfolio.

So thank you very much for the testimony today.

And with that, this hearing is adjourned.

[Whereupon, at 5:02 p.m., the subcommittee was adjourned.]

A P P E N D I X

MARCH 14, 2018

PREPARED STATEMENTS SUBMITTED FOR THE RECORD

MARCH 14, 2018

Opening Statement
Chairwoman Elise M. Stefanik
Emerging Threats and Capabilities Subcommittee
A Review and Assessment of the Fiscal Year 2019 Budget Request for the Department of Defense Science and Technology Programs
March 14, 2018

The subcommittee will come to order.

Welcome everyone to this important hearing entitled: "A Review and Assessment of the Fiscal Year 2019 Budget Request for the Department of Defense Science and Technology Programs."

Defense Secretary James Mattis recently testified that, "our competitive edge has eroded in every domain of warfare – air, land, sea, space and cyber." I couldn't agree more. Our committee, and the Emerging Threats and Capabilities subcommittee in particular, has spent a considerable amount of time reviewing and understanding adversarial threats most notably from China and Russia, while also keeping an eye on emerging technologies such as quantum science, Artificial Intelligence, nanotechnology, synthetic biology, autonomy, and robotics.

We have seen troubling adversarial advances in warfighting systems like hypersonics and directed energy; and adversarial advances in enabling technologies to include high-performance computing and artificial intelligence.

We have also learned that many of our adversaries continue to increase their research and development budgets, and implement National-level, strategic plans. Russia has increased their basic research budget by nearly 25%, and the Chinese have National-level plans for Science and Technology, as well as an approach to lead the world in Artificial Intelligence by 2030. All of these signs point to top-down, government-driven agendas that provide resources and road-maps for strategic collaboration between industry, academia, and civil society. These efforts could propel Russia and China to continue to leap ahead in many of the technology sectors we will talk about today.

But adversarial dominance is not a forgone conclusion. What we learn today and in future hearings must be translated into action – to inform and reform the Department of Defense in support of national level efforts, in order that the United States remains home to the world's leading experts, researchers, and technological breakthroughs.

Artificial Intelligence is one sweeping area that I am particularly interested in from a national security perspective. Next week, I plan to introduce stand-alone legislation that will start the discussion on how we should better organize our government to understand and leverage AI. I look forward to working with my

colleagues on the committee – and also with the Department of Defense – as we craft solutions for this year's NDAA.

Given these challenges, I am very pleased to see a total of $13.7 billion dollars for Science and Technology in the Department of Defense's budget request, an approximate $500 million increase, and 2.3% of the total Defense Budget.

But despite this increase, I remain concerned that our S&T investments represent a small percentage of our overall defense budget. To truly increase lethality and provide a superior technological edge for our warfighters, we should ask ourselves if 2.3% of the total Defense Budget is the correct balance. A properly resourced Science and Technology enterprise, in the long run, reduces risk and – when properly executed – can generate efficiencies within the Department – something we need to keep in mind amidst debates on Sequestration and continuing resolutions.

Now, more than ever, our Science and Technology enterprise and investments play a strategic role and are central to our national and economic security.

This hearing also marks our first open S&T event since the National Defense Authorization Act directed the re-establishment of the position of the Under Secretary of Defense for Research and Engineering within the Department.

As I have said in previous statements, I firmly believe that the Under Secretary for R&E needs to be the prime mover to drive change and foster innovation within the Department. A primary mission of this office should be to provide distinct direction and leadership to energize the Defense Industrial Base, the military services, combatant commanders, and the Department of Defense labs. It must also guide newer initiatives such as the Strategic Capabilities Office, the Defense Innovation Unit – Experimental (or DIUx), and even the Algorithmic Warfare Working Group, and the Defense Digital Service. And while many of these new initiatives have created tremendous momentum and energized a conversation about changing "the culture" of the Department of Defense, much more needs to be done to make these more than one-off, quick gains.

If properly empowered and resourced, I also believe that the Under Secretary for R&E will be in a unique position to drive a national level dialogue for Science and Technology policy that will – in addition to helping maintain a battlefield advantage – energize our domestic Industrial and Innovation Bases and provide technology jobs and opportunities across many of the sectors we will talk about today.

So, we have significant expectations of Dr. Mike Griffin and his office – but we do so while also offering our support and confidence – because the threats we

face from our adversaries demand that we energize and organize our government to ensure that Policy keeps pace with Technology.

To help us through this important topic, we welcome five distinguished witnesses:

- Ms. Mary Miller, Performing the Duties of the Assistant Secretary of Defense for Research and Engineering;
- Dr. Steven Walker, Director of the Defense Advanced Research Projects Agency;
- Dr. Tom Russell, Deputy Assistant Secretary of the Army for Research and Technology;
- Rear Admiral David Hahn, Chief of Naval Research;
  And
- Mr. Jeff Stanley, Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering

Welcome to all our witnesses and we look forward to your testimony.

Thank you again to our witnesses for being here today. Your written statements will be submitted for the record, and please summarize your comments in 5 minutes or less.

HOLD UNTIL RELEASED
BY THE COMMITTEE

STATEMENT TESTIMONY OF

MS. MARY J. MILLER
PRINCIPAL DEPUTY, ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

BEFORE THE UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON ARMED SERVICES

SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

MARCH 14, 2018

Chairwoman Stefanik, Ranking Member Langevin, and distinguished members of the Subcommittee, I am pleased to come before you today to testify about the state of the Department of Defense's science and technology (S&T) program for Fiscal Year 2019 (FY19). I am proud to be here representing the scientists and engineers within the S&T enterprise.

The United States Military remains the best fighting force in the world. We are proud of our men and women who are willing to make the ultimate sacrifice for our country, and we do everything possible to provide them the absolute best training, equipment, and medical care possible. However, one area where we are losing our lead on the global stage, is science and technology.

Technology Transforming the Battlespace

For decades, our adversaries have watched how we conduct warfare. They know how we fight. They've seen our equipment, watched our tactics, techniques and procedures, and determined our concepts of operation. They've had time to assess both our strengths and our weaknesses, and have invested in technology and capabilities that exploit our way of doing business. They don't go against our areas of strengths, they take advantage of our perceived weaknesses.

We live in a time of global access to technology and scientific talent. This easy access is part of the reason we can no longer claim clear U.S. technological superiority within the world. In a world with near equal access to technology, speed is becoming a discriminator. Not just speed of discovery, but speed of delivery. How fast we can develop, adopt, or leverage technology to meet the warfighter's needs and get it into their hands, will determine our ability to outpace our adversaries.

Rapid technological change being exploited includes developments in advanced computing, big data analytics, artificial intelligence, autonomy, miniaturization, additive manufacturing, meta-materials, directed energy, and hypersonics, the very technologies that ensure we will be able to fight and win the wars of the future.

Many of these advances are driven by commercial sector demands, as well as research and development. New commercial technologies will change society, and will ultimately change the character of war. The fact that many of these technological developments will come from the commercial sector means that state competitors and non-state actors will also have equal access. We must accept the reality that we will no longer be able to sustain decades of overmatch like that enjoyed with the First and Second Offset strategies. We need to be adaptive and flexible, and continue to modify our methods so that we remains an unpredictable force to our adversaries. This will become our advantage.

In this competitive environment, the Department must pay much more attention to future readiness, and regaining our Joint Force conventional overmatch over time. We must be willing and able to tap into commercial research, recognize its military potential, and develop new

capabilities and the operational and organizational constructs to employ them faster than our competitors.

Now more than ever is the time to look at ourselves in the same way our adversaries look at us. We are and must remain open-minded to new ways of executing missions. Key DoD laboratory research coupled with industry and academic partnerships, stable budgets, sound investment decisions, and effective acquisition processes are all critical to sustain US technical superiority. The DoD is pushing the envelope with innovative and cutting edge research coupled with new approaches to solving problems in order to ensure U.S. technical dominance.

Threats Exist Across All Domains

Adversaries are moving to next generation capabilities across all domains: air, land, maritime, space and cyber. China and Russia are at parity or surpassing the US in the range, speed, and lethality of some of our weapons and platforms. We are now on-par or outranged by Russian and Chinese rocket and artillery capabilities. Russian and China continue to develop and modernize their extensive nuclear forces and long range precision-guided conventional weapons systems.

China and Russia can hold U.S. and allied positions at risk – amplifying capabilities to detect, track, and target threats in varying conditions, larger volumes, and at greater distances, extend China's integrated air defense systems.

Determining Strategic Priorities in a Global Context

At the beginning of the year, President Trump released the National Security Strategy (NSS) and Secretary Mattis released the National Defense Strategy (NDS). These are two very important documents for the safety and security of the country, and there are strong ties between them and where the innovation enterprise is heading. The common theme in the NSS, NDS, and Defense Science and Technology Enterprise strategy is a strong focus on threat-based mission scenarios.

The risk of conflict is higher now than at any time since the end of the Cold War. Immediate threats in the next year are apparent as our adversaries and malignant actors use all instruments of power, including information and cyber means, to shape societies, markets, international rules and institutions, and international hot spots to their advantage. We must develop new lethal capabilities and accelerate the pace in which we get that capability to the warfighter.

Secretary Mattis is focused on strengthening military readiness by increasing lethality of the force, strengthening our alliances and collaborating with allies whenever and where possible, and forming the Depart of Defense through budget discipline and increased accountability. He has said, "When it comes to security, no one goes their own way in this world alone. Security is always best when provided by a team." The NDS, the first to be released in 10 years, is a

comprehensive strategy intended to pursue urgent change on a significant scale. His solution to strengthening the military (similar to his solution on reforming the DoD business model) is to increase the budget for military spending, repeal the Budget Control Act and make sure that the money is spent recruiting personnel, updating technology and weapons, and making sure we have the capability to fight in more than one realm at a time to the fullest of our ability.

The Need and Path to Modernization

Members of Congress, specifically this subcommittee, have received a lot of information on the current threats and where the U.S. stands on the technology spectrum. The creation of the Under Secretary of Defense for Research and Engineering (USD(R&E)) ensures U.S. technology dominance remains a priority within the Department of Defense. Building upon our strengths and pivoting to lethality, surprise, and continuous speed will help us become a mission-focused department that puts kill chains over systems, heterogeneity over uniformity, and adaptability over performance. In short, allows us to realize warfighting constructs like networked adaptive multi-domain joint battle. The enterprise continues under the USD(R&E) to assess capability gaps and needs by missions vice system or Service, and we remain committed to leveraging Service efforts for resourced integrated prototyping and experimentation activities with outcomes focused on mission effectiveness.

The nation faces a myriad of threats daily. With changing competition, we are forced to stay vigilant in our efforts from basic research to advanced capabilities. The DoD R&E enterprise provides the technological foundations that ensures our military of the future remains the most capable in the world.

We must establish a unifying goal within the Department: to align the Service efforts to ensure that we can achieve a Joint Force that dominates in Networked Adaptive Multi-Domain Joint Battle. In order to achieve this goal, we must establish resources for concepts that will be competitively selected and move to a mission-focused portfolio managed schema, vice individual platform approach. This will ensure that we focus on both new capabilities and operational constructs.

The Science and Technology Enterprise Vision

The Department is in the process of standing up the first Under Secretary of Defense for Research and Engineering. Dr. Mike Griffin, the recently confirmed USD (R&E) will operate with a mission focus. This means that we will move from Service oversight focus to Combatant Command (CCMD) enabling focus. We will assess capability gaps/needs by mission vice system or Service. We will also ensure resources are integrated via prototyping/experimentation activities to leverage Service efforts with outcomes focused on mission effectiveness. We will engage the CCMDs and operators in mission analysis and experimentation to develop new CONOPs.

One of the most important functions of the USD(R&E) is to set the technical direction for the Department of Defense. This is more than just recommending the path forward. To ensure warfighters have what they need, we have to continue to engage with them. The USD(R&E)'s mission is to work with operations personnel to develop new concepts of operations through mission analysis and experimentation, and pilot new acquisition pathways to speed and capability to the warfighter. It is important for our enterprise to utilize intelligence products, technology forecasting, and analysis to inform decisions on investment, prototyping, experimentation and emerging capabilities and concepts of operation. We will focus on driving effectiveness and affordability by addressing drivers in acquisition, testing, and sustainment into the system design phase, setting and adhering to open architectures and interface standards while implementing good systems engineering/cyber resiliency practices. The USD(R&E) will establish and embrace a collaborative culture focused and to pilot new acquisition pathways for speed in providing capability to the warfighter.

Leveraging the Entire R&E Ecosystem

The DoD Labs, Engineering and Warfare Centers and the Defense Advanced Research Projects Agency (DARPA) continue to engage with all partners – global, academia and industry, Federally Funded R&D Centers and University Affiliated Research Centers, , and all our nontraditional assets –Strategic Capabilities Office (SCO) and Defense Innovation Unit Experimental (DIUx). These assets ensure that we win today's fight, design and acquire for the next fight, and push acceleration of science and technology which results in driving ideas to capabilities.

The DoD has 63 laboratories and engineering/warfare centers that provide expertise and insight to enhance our warfighters capability. Those labs and centers are the foundation of the Department.

DARPA focuses on making pivotal investments in breakthrough technologies for national security. DARPA explicitly reaches for transformational change instead of incremental advances in the development of emerging technologies for use by the military. Since its inception, the agency's mission is ensuring that the United States avoids further technological surprise.

SCO's mission is to create innovative ways of using existing military and commercial systems to win tomorrow's war surprisingly, and buy time for future technologies to emerge. These capabilities bolster our conventional deterrence advanced adversaries, while assuring allies and partners.

DIUx was established to accelerate commercial innovation to the warfighter in order to meet the changing demands of today's strategic and technological environment. Their mission is to pilot cultural change within the DoD – to break with past paradigms of military-technical advantage and to become fast adapters, as opposed to sole developers, of technology, integrating the advanced commercial capabilities necessary for strategic advantage.

Smaller programs such as the Small Business Research (SBIR) program and the Small Business Technology Transfer (STTR) are highly competitive programs that encourage domestic small businesses to engage in Federal Research and Development (R&D) that has the potential for commercialization. Through a competitive awards-based program, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit as it meets its specific research and development needs.

In 2012, we established 17 cross-cutting technology working groups composed of Service/Agency Subject Matter Experts, called Communities of Interest (CoIs), that sought to reduce perceived redundancy and synchronize the DoD research being done across three main focus areas: mission, systems/capabilities, and technology. These CoI's not only provide invaluable capability gap insight, they have created stronger collaboration among the Services to address shared problems. This collaboration has increased the Enterprise's efficiency and effectiveness in addressing the Department's capability gaps.

Workforce

All of these efforts and programs are not possible without our scientists and engineers who are doing groundbreaking and innovative work. They are embracing the hard challenges our military faces every day, seeking to better understand the Warfighter's problems and working diligently on solutions. Our ability to continue to maintain our technological edge in the future depends on the next generation of DoD scientists and engineers. DoD has a responsibility and critical interest in the development of STEM-literate individuals to maintain and grow the talent pool to ensure technical dominance in the future.

The Department of Defense laboratories throughout the US where cutting edge research and development is occurring every day in support of our Nation's Warfighters. We employ nearly half (46 percent) of all scientists and engineers within the Federal Government (>100,000 as of December 2015).

But DoD has a growing need for increasing the number of Scientists and Engineers in their workforce. As I mentioned earlier, technology is global and accelerating at a rapid pace. New technical competence and expertise is required. It is incumbent upon us to help develop (and maintain) a STEM pipeline.

The Department recognizes that we need more than just the best technology. We need the best people too. That's both a challenge and an opportunity. A challenge because we require a STEM workforce made of predominately US citizens. An opportunity because we have tough problems to solve that allow for new approaches. Because we offer unique experiences like apprentice and intern programs that allow high school and college students to directly apply what they are learning in the classroom, to get a firsthand view of what it means to be a laboratory scientist. An example of one of these opportunities is our Science, Mathematics and Research for Transformation (SMART) scholarship-for-service-program.

We strive to provide the best STEM opportunities and education programs to help train, maintain, and retain the best STEM workforce available. For the Department of Defense, for our Defense Industrial Base, and for the Nation as a whole.

Conclusion

The U.S. military has long relied on high quality people, technological superiority, innovative operational and organizational constructs, and our unmatched ability to fight as a Joint Force. We are addressing the erosion of technological superiority by identifying and investing in innovative technologies and processes to sustain and advance America's military

As the Department looks to the future, we strive to ensure that the nation is the first to develop and adopt the novel capabilities made possible by bold, risk-tolerant investments in high impact technologies. The innovation enterprise remains committed to not only creating new potential technologies but also to help transition those technologies to the Services or other sectors where they can be implemented in support of national security.

Our goal must always be to ensure that our Soldiers, sailors, airman, and Marines always have the scientific knowledge, the decisive technology, the advanced systems and tools, and the material edge to succeed when called upon. Our Research and Engineering Enterprise measures its success in the security of the nation and the success of our warfighters.

Let me close by thanking the committee for its strong interest in and support of the Department's Research and Engineering efforts as we work to discover, design and deliver technology capabilities our warfighters will need in the future. Thank you.

Ms. Mary J. Miller
Performing the Duties of Assistant Secretary of Defense for Research and Engineering

Ms. Mary J. Miller is currently performing the duties of Assistant Secretary of Defense for Research and Engineering within the Office of the Under Secretary of Defense for Research and Engineering. In April, 2016, she joined the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics as the Principal Deputy Assistant Secretary of Defense for Research and Engineering. She is responsible for the Department of Defense (DoD) strategies and supporting plans to develop and leverage technologies needed to ensure continued U.S. technological superiority. She provides leadership, establishes policy and guidance for the development and execution of the DoD Science and Technology (S&T) enterprise, with an annual budget in excess of $12 billion. She oversees matters from basic science and capability prototyping to research and engineering at the 63 DoD laboratories; promotes coordination and cooperation across DoD, between DoD and other federal and non-federal agencies and organizations and ensures technological exchange with allied and friendly nations.

Prior to that she served three years as the Deputy Assistant Secretary of the Army for Research and Technology. She was responsible for policy and oversight of the Army's research and technology program, which spans 16 Laboratories and Research, Development and Engineering Centers, employs nearly 12,000 scientists and engineers and has a yearly budget that exceeds $2.4 billion. Ms. Miller was charged with identifying, developing, and demonstrating technology options that inform and enable effective and affordable capabilities for Soldiers. She was also responsible for developing an S&T strategy that is responsive to Army needs from the near term (5 years) stretching out through the far term (more than 20 years). Her S&T portfolio covered basic research through the development and demonstration of components, subsystems, Manufacturing Technology, and technology system prototypes.

Between 2010 and 2013, Ms. Miller served as the Deputy Program Executive Officer for Soldier, where she was the principal civilian for the Department of the Army responsible for the design, development, procurement, fielding, and sustainment of a portfolio with more than 460 products/systems and a $3 billion budget. Her work encompassed virtually everything a Soldier wears or carries.

From 2005 to 2010, Ms. Miller served as the Director for Technology, within the Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology. There she was responsible for the oversight and coordination of the Army's S&T efforts to transition technology in support of Army acquisition programs. She also served as the U.S. National Representative on the Weapons Panel of The Technology Cooperation Program.

Ms. Miller received a B.S. in Electrical Engineering from the University of Washington, an M.S. in Electrical Engineering, Electro-Physics, from George Washington University and an M.B.A. from the University of Tennessee. Ms. Miller was selected in 2005 to the Senior Executive Service and is Defense Acquisition Workforce Level III certified in Program Management; Engineering; and Science and Technology Management.

Updated: March 2018

Statement by Dr. Steven Walker
Director, Defense Advanced Research Projects Agency

Before the
Subcommittee on Emerging Threats and Capabilities
Armed Services Committee, U.S. House of Representatives

A Review and Assessment of the Fiscal Year 2019 Budget Request for Department of Defense Science and Technology Programs

March 14, 2018

Introduction

For 60 years, DARPA has held to a singular and enduring mission: to make consequential investments in breakthrough technologies for national security. The genesis of that mission and of DARPA itself dates to a commitment by President Eisenhower that the United States would be the initiator of strategic technological surprise. Working with innovators inside and outside of government, DARPA has repeatedly delivered on that mission, transforming revolutionary concepts and even seeming impossibilities into practical capabilities. The ultimate results have included not only game-changing military capabilities such as precision weapons and stealth technology, but also features of modern civilian society such as the Internet, automated voice recognition and language translation, and Global Positioning System receivers small enough to embed in mobile consumer devices.

DARPA explicitly reaches for transformational change instead of incremental advances, but it does not perform its engineering alchemy in isolation. It works within an interlocking ecosystem of diverse collaborators that includes academic, corporate and governmental partners with the collective goal to create innovative strategic opportunities and novel tactical options.

In the six decades since DARPA was established, the world has changed dramatically—and the rate at which those changes have occurred has in many respects increased. Those changes include some remarkable and even astonishing scientific and technological advances that, if wisely and purposefully harnessed, have the potential not only to ensure ongoing U.S. military superiority and security, but also to catalyze societal and economic advances. At the same time, the world is experiencing deeply disturbing technical, economic, and geopolitical shifts that pose potential threats to U.S. preeminence and stability. These dueling trends of unprecedented opportunity and risk deeply inform DARPA's most recent determination of its strategic priorities.

Accordingly, the following testimony includes relevant details about: **1)** DARPA's strategic priorities placed within their global context; **2)** how DARPA is accelerating new technologies to meet emerging threats, and, finally, **3)** components of the agency that are central to the identification of emerging threats as well as the successful transition of future capabilities.

Determining Strategic Priorities in a Global Context

Since the beginning of the year, President Trump has released the National Security Strategy (NSS) and Secretary Mattis has released the National Defense Strategy (NDS). These are two very important documents

for the country and there are strong ties between them and where DARPA is heading. The common theme in the NSS, NDS, and DARPA's strategy is a focus on threat-based mission scenarios. To address myriad threats to national security, DARPA is working to achieve new, revolutionary capabilities based on four focus areas:

- ***Defending the homeland*** from varied threats includes developing cyber deterrence capabilities, bio-surveillance and biothreat defense techniques, and the ability to sense and defend against weapons of mass terror/destruction.
- ***Deterring and prevailing against peer competitors*** in Europe (a stand-in scenario) and in Asia (a stand-off scenario) requires new thinking. The U.S. can no longer be dominant across all scenarios, but it needs to be highly lethal in select ones. This lethality needs to be surprising to peer competitors. Realizing new capabilities across the land, sea, and air domains is important, but space and the electromagnetic spectrum are just as important.
- ***Effectively prosecuting stabilization efforts across the globe*** requires us to get better at fighting differently and in different environments. Capabilities to address gray-zone conflict and 3D city-scale warfare, along with the development of rigorous and reliable models to predict adversarial moves prior to engagement, are critical.
- ***Foundational research*** in science and technology underlies all of DARPA's grander pursuits and is what makes possible never-before-seen capabilities. Ultimately, the goal of the agency's fundamental R&D investments is to ensure that U.S. warfighters have access to the most advanced technologies. Research funded by DARPA in the near term explores science and technology that will lead to "leap ahead" solutions for specific current and future challenges to military readiness across multiple operational domains.

Accelerating new technologies to meet emerging threats

The cycle of innovation at DARPA is alive and well today—though the agency's approach to developing breakthrough technologies has evolved with advances in the larger U.S. innovation ecosystem. Increasingly, DARPA is taking advantage of the extraordinary creativity and pace of the private commercial sector and then adding customized Government-developed components to create specialized military tools and capabilities more precise and powerful than anything available elsewhere in the world.

Defend the Homeland

The principal task of the Department of Defense is to defend the Nation and its interests around the world. So too is defense the raison d'être for DARPA. The following section highlights recent DARPA developments at various stages of transition. Together, these advances represent a portfolio of progress that promises to keep the Nation secure while DARPA's innovators extend the agency's reach to new and even more exciting technological frontiers.

Detecting Radiological Threats Before It's Too Late

Perhaps no domestic security threat today exceeds that of a nuclear or radiological "dirty bomb" detonation. Current sensors can detect high-emitting radiological materials that could signal such mass-terror devices, but are too large and expensive to deploy widely to fully protect an urban area or major transportation hub.

DARPA's SIGMA program has successfully created high quality, handheld radiological sensors—the size of an average smart phone—at a fraction the cost of today's devices. SIGMA developed not only that hardware but also the software to monitor thousands of those mobile detectors in real time—an essential capability to discern the movement of nuclear materials before they can be incorporated into a terrorist's weapon.

In collaboration with officials in the Washington, D.C., metropolitan area and the Port Authority of New York and New Jersey, DARPA in 2016 tested the devices and networking system at critical transportation hubs and on a city-wide scale involving 1,000 detectors. That test showed the system could fuse the data provided by all those sensors to create minute-to-minute situational awareness of nuclear threats. Working in close cooperation with the Department of Homeland Security, DARPA's technology has been on track for deployment in multiple locations. Also, DARPA is now looking at expanding SIGMA's capabilities to include threat detection for other harmful elements such as chemicals, explosives, and biological and radiological agents.

Defending the Worlds' Largest Network

Another research effort DARPA is working on that is already contributing to national security is called Network Defense. The program, which launched in 2015, sifts through terabytes and terabytes of Department of Defense Information Network (DODIN) data to sniff out harmful network events. Each month, DODIN users generate an order-of-magnitude more data than existing analysis capabilities can possibly process. To address this analytical deficit, DARPA recently transitioned elements of its Network Defense program to the United States Cyber Command. Working with members of the Army's Cyber Protection Teams (CPTs) as well as U.S. CYBERCOM, DARPA researchers were able to identify three Advanced Persistent Threats (APT) domains within the first few days of operation. As the program progressed, more than five crime-ware infections were discovered and several other network anomalies were referred for more detailed investigation.

Network Defense has also produced results for commercial transition partners. In late 2016, DARPA researchers identified a botnet, in addition to an insider threat, attacking a Fortune 500 partner. In all, Network Defense researchers developed more than 44 scalable mathematical techniques that are currently applied in commercial and military contexts, uncovering, to date, in excess of 60 cybersecurity exploits.

The SIGMA and Network Defense programs are just two representative samples of how DARPA is working with its government partners to defend the homeland from attack. In the next section, other program examples show more lethal options the Nation will soon have at its disposal to both deter and prevail against high-end adversaries.

Deter and Prevail Against Peer Adversaries

To present adversaries with surprising warfighting scenarios that create dilemmas within or completely disrupt their decision calculus, we must disrupt our own warfighting enterprises and provide for adaptive lethality across the physical domains of air, land, and sea. Big monolithic platforms that are designed, built, and procured to do everything cost too much, take too long to field, and are usually technologically out of date by the time they are fielded. DARPA seeks a new asymmetric advantage—one that imposes complexity on adversaries by harnessing the power of dynamic, coordinated, highly autonomous, and flexible architectures.

Delivering Long-Range Anti-Ship Capabilities

One example of a flexible, semi-autonomous capability, is the Long Range Anti-Ship Missile (LRASM), which was developed jointly by DARPA and the Office of Naval Research (ONR) and began in 2009. LRASM is a precision-guided, survivable standoff missile that will protect U.S. Navy surface ships in a highly contested environment. After successful initial flight tests by DARPA and ONR, DARPA stood up a rapid deployment office with the Navy and Air Force, located within the agency's headquarters, to insure a seamless and speedy leap to operational capability this calendar year.

Hypersonics

Our ability to field hypersonic systems constitutes another arena of national defense that DARPA is pursuing aggressively and with a particular sense of urgency due to the rising pace of related research by peer adversaries. Hypersonic flight—which refers to flight velocities of more than five times the speed of sound—offers a number of strategic advantages. Namely, the potential for military operations from longer ranges with shorter response times and enhanced effectiveness compared to current military systems.

Looking beyond the early investigative stages of the program, DARPA is now developing hypersonic technology demonstrations for operational capabilities. Those demonstrations are on schedule to occur in late 2019, and the agency, working with the Air Force, is putting in place a "LRASM-like" transition activity to develop a hypersonic weapon early operational capability. Additional FY19 funds for DARPA's hypersonics programs will allow the agency to bring on additional resources to add more flights and do more evaluation prior to a hand-off to the Air Force.

Effectively prosecuting stabilization efforts

DARPA's mission is to look beyond the reality of today and to focus on the potentiality of the future. Specifically, its job is to identify current or future advances that have the potential to bend today's security trajectories— advances that, years from now, could disrupt the stability the country enjoys as well as advances that, over the same period, could enhance national and global stability.

Invariably, stabilization efforts also require U.S. soldiers to be on the ground to remove threats and project strength. That, of course, requires putting American lives in danger. As an agency with vast technical means and know how, DARPA sees it as a moral obligation to attend to and roundly improve all aspects of warfighter performance.

Squad X Core Technologies (SXCT)

To succeed in their missions, military units must have a robust, multi-faceted picture of their operational environments, including the location, nature, and activity of threats and allied forces around them. Technology is making this kind of rich, real-time situational awareness increasingly available to airborne and other vehicle-assigned forces, along with a capacity to deploy precision armaments more safely, quickly, and effectively. Dismounted infantry squads, however, have so far been unable to take full advantage of some of these highly effective capabilities because many of the technologies underlying them are too heavy and cumbersome for individual Soldiers and Marines to carry or too difficult to use under demanding field conditions.

DARPA's Squad X Core Technologies (SXCT) program is currently developing novel technologies that could be integrated into user-friendly systems that would extend squad awareness and engagement capabilities without imposing physical and cognitive burdens. The goal is to speed the development of new, lightweight, integrated systems that provide infantry squads unprecedented awareness, adaptability, and flexibility in complex environments, and enable dismounted Soldiers and Marines to more intuitively understand and control their complex mission environments.

Foundational Research and Technologies

DARPA's job is to change what's possible—to do the fundamental research, the proof of principle, and the early stages of technology development that take "impossible" ideas to the point of "implausible and then, surprisingly, possible." No other agency within the Defense Department has the mission of working on projects with such a high possibility of producing truly revolutionary new capabilities—or such a high possibility of failure. Indeed, a big part of DARPA's particular expertise is seeking high-pay off capabilities by managing risk in ways that help keep the innovation pipeline flowing. In the previous section, several

existing programs were detailed, below, however, we will explore new, foundational-research efforts that promise to impact national security like the ARPAnet and Have Blue.

One of these foundational technology areas is advanced electronics. DARPA has had a key role over the years in advancing the state of the art in electronics, especially in the semiconductor space. Today, the advanced electronics industry is at an inflection point. Design work and fabrication now required to keep on pace is becoming ever more difficult and expensive, and the pace of homegrown innovation is slowing while countries such as China—which is significantly behind the U.S. and others in semiconductor capability now—are investing huge sums of government-directed private capital to acquire on-shore semiconductor design and manufacturing capabilities.

Electronics Resurgence Initiative

In 2017 DARPA launched the Electronics Resurgence Initiative (ERI), which aims to create "leap ahead" technology that will marginalize traditional circuit technology and create a wave of new U.S. development and economic opportunity. Over the next four years, ERI will commit hundreds of millions of dollars to nurture research in advanced materials, circuit design tools, and new system architectures.

The foundation for the Initiative has been building for a number of years in the form of existing MTO programs. Another major ERI component is an extensive university-based program—the Joint University Microelectronics Program (JUMP)—that MTO and corporate partners have organized to build up a fundamental research base in fields underlying microelectronic technologies. Corporate partners include ARM, IBM, Intel, Lockheed Martin, Northrop Grumman, Raytheon, and Samsung, among others.

Safe Genes

From electrons to genes, DARPA recognizes that the current pace of scientific progress at the fundamental level poses both challenges and opportunities. That is, in large part, why DARPA created the Safe Genes program—to gain a basic understanding of how gene editing technologies function; devise means to safely, responsibly, and predictably harness them for beneficial ends and address potential health and security concerns related to their accidental or intentional misuse.

Achieving such ambitious goals requires more complete knowledge about how gene editors, and derivative technologies including gene drives, function at various physical and temporal scales under different environmental conditions, across multiple generations of an organism. In parallel, demonstrating the ability to precisely control gene edits, turning them on and off under certain conditions or even reversing their effects entirely, will be paramount to the safe translation of these tools to practical applications.

Explainable Artificial Intelligence

The deliberate and safe exploration of revolutionary technologies is a common theme at DARPA. Where there is bluster, hype, and uncertainty surrounding new innovations, DARPA cuts through to find the ground truth. This is evident in the agency's approach to gene editing and in the burgeoning field of artificial intelligence. For more than four decades DARPA has been driving artificial intelligence research, deftly separating science from science fiction. Early "first-wave" research by the agency resulted in expert systems, powerful ways to interact with computers, knowledge representation used in electronic commerce, enhanced operational planning tools, industrial robots, and self-navigating vehicles. We are now entering the "second wave" in which machine learning techniques, powered by inexpensive computing, has produced breakthroughs in broad areas of our everyday experience, including interaction with computers, language translation, image and video analysis, and the beginning of autonomous vehicles for consumers. DARPA's vision, focus, and funding made this possible.

DARPA is now framing and leading the "third-wave" of AI, in which contextual reasoning, the ability to effectively convey to human users how and why specific decisions are made. DARPA is also advancing the theory of AI to ensure that systems are robust and efficient as the technology is embedded within critical systems across society. The program at the center of this push is called Explainable AI or XAI.

Recognizing that the Department of Defense is facing challenges that demand more intelligent, autonomous, and symbiotic systems, XAI aims to create a suite of machine learning techniques that produce explainable models, while maintaining a high level of prediction accuracy so human users understand, appropriately trust, and effectively manage the emerging generation of artificially intelligent partners. Through XAI, new machine-learning systems will have the ability to explain their rationale, characterize their strengths and weaknesses, and convey an understanding of how they will behave in the future.

As the above highlights reveal, powerful technology trends are fueling many of DARPA's programs. Other areas where the agency is making investments include: materials, human-machine symbiosis, rapid access to space, autonomous systems, weapons effects, encryption, and more.

Keys to Success

In order to attend to the myriad threats and challenges posed to the Nation, DARPA remains committed to the principles that have garnered it success for sixty years. First and foremost, DARPA is a projects agency. The agency starts projects *and*, if prudent, stops projects; it insists on metrics and milestones to measure progress; and if DARPA's researchers prove something audacious can be done, then it very well may have the potential to gird our security position and even change the world. As such, DARPA will continue to use rigorous, time-tested methods—unique to the agency—to ensure it initiates and shepherds programs that anticipate future threats and make significant contributions to national security.

DARPA projects address the highest payoff, highest risk, and most forward-looking technology concepts in deciding what investments might have the most significant impact in addressing future national security challenges. DARPA investments seek to address seemingly impossible technical barriers in demonstrating "proof of concept" for solutions to these challenges. This model has a distinguished track record of producing answers to future questions that span operational environments while sometimes leading to applications in the commercial sector.

The next guiding principle of DARPA is strong partnerships with others in the science and technology ecosystem, including the Services, defense companies, small and large commercial entities, startups, allied nations, academics, and our stakeholders in the executive and legislative branches of government. DARPA cannot do what it does as an agency without support from these elements, as noted above in program examples like ERI and the agency's hypersonics research. The new leadership team at DARPA is actively meeting with and strengthening relationships with senior military leadership—relationships based on trust and performance—with the goal of showing how the agency can take ideas perceived to be impossible and make them possible.

Finally, the third priority in this 60th year of DARPA, is continuing to ensure we have the best and most creative people in the world. DARPA comprises approximately 220 government employees in six technical offices, including nearly 100 program managers, who together oversee about 250 research and development programs. This small group of uniquely dedicated people represent the talent responsible for maintaining acute awareness of emerging technology trends and capitalizing on them before others do.

DARPA goes to great lengths to identify, recruit, and support extraordinary program managers who are at the top of their fields and are hungry for the opportunity to push the limits of their disciplines. These leaders, who are at the very heart of DARPA's history of success, come from academia, industry and government agencies for limited stints, on average, of just three to five years. That inherent sense of deadline fuels the

signature DARPA urgency to achieve success in less time than might be considered reasonable in a conventional setting.

Program managers address challenges broadly, spanning the spectrum from deep science to systems to capabilities, but ultimately they are driven by the desire to make a difference to national security. They define their programs, set objectives, meet with their performers, and assiduously track progress. All the while, they are probing for the next big thing in their fields by engaging as peers with leaders in the scientific and engineering community to identify new challenges and potential solutions.

The DARPA team is one whose collective energy not only propels the agency, but also invigorates and inspires people across the wider community with which it works—defense companies large and small, commercial startups, universities, government agencies and labs, and our close partners across the Department of Defense. The DARPA team revels in the opportunity to attack pressing and previously intractable problems—all in the context of public service.

Conclusion

DARPA focuses every day on assuring the success of its individual programs. But the ultimate objective of the agency's work is the achievement of major, unexpected advances in national security capabilities. DARPA's record in this regard is unrivaled. Precision-guided munitions, stealth technology, unmanned systems, advanced ISR, and infrared night vision have individually and together induced remarkable changes in how U.S. forces fight and win. At the same time, the enabling technologies behind these military capabilities—new materials, navigation and timing devices, specialized microelectronics, advanced networking and artificial intelligence, among others—helped lay a foundation for private-sector investments that extended far beyond the battlefield to create products and services that have changed how people live and work. In a further amplification of impact, these sophisticated commercial products and services are themselves being harnessed by DARPA and other DoD agencies to advance national security and ensure military advantage.

As DARPA looks to its next 60 years, it promises to continue to be a bold, risk-tolerant investor in high-impact technologies so the Nation can be the first to develop and adopt the novel capabilities made possible by such work. DARPA is deeply committed to this mission in the furtherance of national security, and with continued support from Congress, as well as the backing of the Pentagon and partners in the broader S&T ecosystem, it will succeed.

Dr. Steven H. Walker
Director, Defense Advanced
Research Projects Agency

Dr. Steven H. Walker was appointed Director of the Defense Advanced Research Projects Agency (DARPA) on November 13, 2017. He served as the deputy director of the agency from October 2012 to December 2016.

Prior to his return to DARPA in 2012, Dr. Walker served as Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering, Office of the Assistant Secretary of the Air Force for Acquisition, Washington, D.C. He was responsible for developing the technology investment strategy for the Air Force's annual $2 billion science and technology program and for providing functional management of more than 14,000 military and civilian scientists and engineers.

Dr. Walker has more than 30 years of experience in the civil service. He began his engineering career in the Air Force Research Laboratory's (AFRL) Air Vehicles Directorate in Dayton, Ohio, developing airplane exhaust system thrust-vectoring concepts and aero-acoustic prediction methodologies. Subsequent assignments include Program Manager of the Unsteady Aerodynamics and Hypersonics Research Program at the AFRL's Air Force Office of Scientific Research in Arlington, Va., and Special Assistant to the Director, Defense Research and Engineering, at the Pentagon. Dr. Walker also previously served in DARPA's Tactical Technology Office as a program manager, deputy director, and director. As a program manager, he initiated the $500 million DARPA/Air Force Falcon program to develop and flight-test technologies for long-duration hypersonic flight and affordable, responsive space lift.

Dr. Walker holds Doctor of Philosophy and Bachelor of Science degrees in Aerospace Engineering from the University of Notre Dame and a Master of Science degree in Mechanical Engineering from the University of Dayton.

Dr. Walker is a member of the Senior Executive Service and a Fellow of the American Institute of Aeronautics and Astronautics; he received the AIAA Hap Arnold Award for Excellence in Aeronautical Management in 2014. He has also been awarded the Presidential Rank Award, the Air Force Meritorious Civilian Service medal, and the DoD Exceptional, Meritorious, and Distinguished Civilian Service medals.

RECORD VERSION

STATEMENT BY

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BEFORE THE

SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES
COMMITTEE ON ARMED SERVICES
UNITED STATES HOUSE OF REPRESENTATIVES

ON

A REVIEW AND ASSESSMENT OF THE FISCAL YEAR 2019 BUDGET REQUEST FOR DEPARTMENT OF DEFENSE SCIENCE AND TECHNOLOGY PROGRAMS

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COMMITTEE ON ARMED SERVICES

Chairwoman Stefanik, Ranking Member Langevin, and distinguished members of the Subcommittee, I would like to thank you for the opportunity to discuss the United States Army's program for Science and Technology (S&T) for Fiscal Year (FY) 2019. The committee plays a vital role in supporting Army S&T as the program seeks to ensure that the U.S. Army modernizes to meet future readiness requirements.

The Army's and future operational environment will demand land power dominance with increased flexibility, adaptability, and speed of responsiveness; mechanisms to mitigate or eliminate tactical surprise; improved joint interoperability and compatibility; an ability to effectively accommodate evolving alliances and partnerships; and seamless Soldier proficiencies across functional domains.

As a means to address current capability shortfalls and outpace anticipated threats, the Army S&T enterprise will pursue foundational technology developments for the future; leverage organic capacity and the capacity of our partners; mature technologies into innovative, affordable, and sustainable solutions; and make investments today in fundamental science and technology initiatives that will ensure breakthroughs that will yield affordable, decisive advantages for the future. The Army's S&T program supports the top modernization priorities established by the Secretary of the Army and the Chief of Staff of the Army (CSA).

Operating Challenges

Strategic land power dominance is critical to the U.S. Army for prompt, sustained, and synchronized operations with a force customized to the mission and poised to execute all its missions in all functional domains. Army S&T portfolio is focused on the Army's futures investment to allow it to fight tomorrow's wars with the right equipment.

The S&T enterprise faces a number of challenges, and is taking action to improve outcomes and efficiencies. Portfolio investments guide breakthrough research and technology innovation by creating, adapting, and developing leading edge technologies for future Army capabilities; innovating technical solutions to rapidly respond to urgent

Warfighter needs; and informing affordable and achievable requirements through experimental prototyping and demonstrations to leverage early Soldier input and drive down technical risk.

Over the past few years, the S&T Portfolio focused on near-term projects oriented on current requirements and improvements to current systems. After a critical review by Army stakeholders, the S&T Portfolio is being adjusted to meet the Army's needs to deter strategic competitors in the mid-and far-term, consistent with the Secretary of the Army and Chief of Staff of the Army and strategic planning guidance.

As a result, greater than $1.0B in S&T funding was redirected from near-term to mid-term projects, reducing investments in counterinsurgency programs and increasing/accelerating investments to prepare for and deter strategic competitors. This adjustment is impacting FY19-23, which will allow S&T to maintain its investments to guide breakthrough research and technology innovation.

Science and Technology Development

The nation's landpower dominance will continue to rely on significant S&T advances to ensure competitive advantage to the U.S. Army and the joint force. As a safeguard against technological surprise, the Army's S&T portfolio is dedicated to futures investments that provide and inform technological options to our senior leadership and acquisition programs. These portfolio investments preserve S&T development continuity to maintain leading edge technologies; enable a broad technology outlook; and go beyond the limits of threat assessments to consider the "possible" and "unthinkable" to prevent tactical, operational, and strategic discontinuities.

Supporting Modernization

The Secretary of the Army and the Chief of Staff of the Army have established six top priorities to address the full spectrum from existing and emerging threats. Army S&T is fully involved with supporting the six key Army Modernization efforts:

Long Range Precision Fires

The Army's top modernization priority is to regain dominance in artillery and missile system range, lethality, and target acquisition with respect to strategic competitors. Army S&T has a multifaceted program to develop extended range capabilities for both cannon artillery and missile systems, as well as the supporting systems and technology necessary for their successful use in combat. A major change for FY 19 is an increased focus on engagement of multi-domain and moving ground and maritime targets with the initiation of the Land Based Anti-Ship Missile effort and the Extended Range Artillery Munition Suite.

Next Generation Combat Vehicle (NGCV)

The goal in this area is to provide an experimental prototype in FY 20 for Soldier evaluation. Several key technology efforts are scheduled to complete at end of FY19 including Modular Active Protection System (MAPS), Advanced Powertrain Demonstration, Vehicle Electronics Demonstrator, Advanced Running Gear, Combat Vehicle Survivability Underbody Blast Effort, and Vision Protection for Vehicles.
A major focus area is robotics and autonomy enabled systems including artificial intelligence. This area includes developing purpose-built autonomy enabled systems and exploring upgrading current systems to be optionally-manned. There are significant challenges to overcome, but the potential increase in capability is worth the effort.

Future Vertical Lift (FVL)

The FVL effort is vital to ensure that Army Aviation can fly, fight, and survive in the future Anti-Access/Area Denial environment. The major focus areas of FVL S&T are Platform Design and Structures; Power; Unmanned Aircraft System Autonomy and Teaming; and Mission Systems. A major achievement occurred in one of the flight demonstrators under the Joint Multi-Role Technology Demonstrator project. Two successful flights demonstrated several revolutionary technologies, including advanced composites/low-cost manufacturing, active vibration control, and improved design and analysis tools.

Networks/C3I

The goal of S&T's Network/C3I investments is to provide the Soldier with assured communications in contested environments through situationally aware, intelligent networks, and autonomously routing of information over resilient communications links. Significant changes for FY19 are increased investments in tactical network and communications, and quantum computing for assured position, navigation, and timing (PNT) in Zero-GPS environments. A major effort is work on Modular Radio Frequency Communications to provide connectivity in contested and congested environments.

Air and Missile Defense (AMD)

The goal of S&T's effort in AMD is to develop and demonstrate technologies to defend against enemy air attack at extended range. A major change in FY19 is increasing focus on developing and demonstrating technologies to counter Maneuver Short Range Air Defense Missile Threats. To enable a layered defense, there are four major focus areas: Missiles, Directed Energy, Gun-based Air Defense, and Battlefield Sensors and Force Protection. The Army's High Energy Laser efforts are showing a great deal of promise. During FY17, the Army's 58 kilowatt Robust Electric Laser Initiative laser was successfully fired multiple times and achieved an electrical-optical efficiency of 43%, a record for solid state lasers. This laser was delivered to U.S. Army Space and Missile Defense Command for integration for the High Energy Laser Tactical Vehicle Demonstrator risk reduction demonstration scheduled for 4th Quarter of FY18.

Soldier Lethality

The Soldier Lethality modernization priority is focused on improving Soldier performance through increased mobility, enhanced lethality, and improved situational awareness. A major challenge to Soldier Lethality is how incorporating improved technologies can drive up the weight a Soldier must carry during a mission. The major focus areas for Soldier Lethality S&T are weapons and ammunition technologies, protection technologies, cognitive and physical performance measures, training to include the Synthetic Training Environment, and mission support capabilities such as

situational awareness sensors and displays, dismounted power and energy technologies, and Soldier and Small Unit sustainment capabilities.

The technologies that support these priorities are: Artificial Intelligence, ultra-secure communications, robotics, virtual reality, internet of things, energetics, Directed Energy, and ultra-designed materials. This list is not limiting but rather focusing, and as research proceeds, it is subject to review and revision.

I. Artificial Intelligence (AI) – The artificial intelligence and machine learning effort extends commercial sector advances to solve military challenges. Reliance of the Warfighter on AI at the tactical edge requires the AI to be multi-faceted. Research in AI involves the development of a suite of AI-inspired and machine learning techniques and systems to assist Soldiers in dynamic, uncertain, complex operational conditions.

II. Ultra-Secure Communications – The ultra-secure communications effort is two-fold. It seeks to develop short-haul hybrid communication networks with automated and intelligent switching capabilities and long-haul, distributed quantum communication networks that are tamper-evident and can provide more efficient processing of information for data-to-decisive actions.

III. Robotics – The Robotics program is developing ground and air capabilities to advance the state of the art in military robotics and autonomous systems (RAS). It involves understanding capabilities, strengths, and limitations of RAS systems providing iterative feedback to both the S&T and Combat Developer communities. One example in the area of robotics is the combat vehicle robotics (CoVeR) – which builds on Wingman Joint Capability Test Demonstration capability to expand autonomous vehicle mobility to tracked platforms in operational environments at tactically relevant speeds.

IV. Virtual Reality – The virtual reality effort will bring improvements to both Soldier training and to operational situational awareness. Training using virtual reality, along with constructive and live environments, is known as the Synthetic Training Environment, and will allow responsive and reconfigurable

environments that immerse human senses in mixed-reality environments including physical elements, and providing touch and feel to simulate objects, such as obstacles and walls.

V. Internet of Things (IoT) – We are using an internet of things approach for networking the battlefield of the future – converging and integrating various sources of information, communication systems, and analytical resources for faster, optimal decisions. The key difference between industry and military IoT is the deceptive and adversarial nature of the battlefield, its large scale and extreme heterogeneity.

VI. Energetic Materials – The energetic materials effort is opening insights into new ways to store energy and synthesize energetic compounds and approaches for releasing the stored energy at the desired time scales to achieve a substantially enhanced energetic output. The potential benefits are a class of energetic materials with 10 times the energetic release level of current explosives that will lead to increased lethality, smaller and lighter munitions, and higher performance gun and missile propellants.

VII. Directed Energy – In the past few years, diode-laser technology advances have made solid state High Energy Laser (HEL) systems feasible which may provide cost effective, lightweight, mobile HEL technology that affords protection against RAM, UAS, and cruise missiles in the future. Other key technology areas for Army S&T include non-traditional laser cooling systems and methods to mitigate adverse atmospheric effects and track targets in high clutter environments. These efforts are done in collaboration with the Joint community and the Directed Energy Joint Technology Office.

VIII. Ultra-Design Materials – All of the areas highlighted above benefits from the development of new materials with unique properties not available in nature. We are developing a materials-by-design approach to create transformational protection, energetic, electronic, and bio/bio-enabled materials.

Infrastructure Modernization

State-of-the-art technical facilities are essential to ensuring that the Army's S&T enterprise is positioned for discovery and maturation of technologies critical to Army and joint force operations into the deep future. Due to a myriad of contributing factors, many technical facilities that are leveraged by the S&T enterprise have become obsolete and would greatly benefit from revitalization and recapitalization. Upgrades made to existing facilities and/or minor construction of new facilities would improve safety, innovation efficiencies, and enterprise-wide poise for exploration of emerging scientific fields that would be difficult, if not impossible, to pursue using current facilities.

An enterprise-wide approach to technical infrastructure modernization, centered on four primary areas, is expected to lead to an integrated system of facilities accessible to technical personnel from across the S&T enterprise. This approach is focused on:

- Modernizing the Army's organic technical infrastructure.
- Informing technical construction of partner facilities.
- Engaging in Public-Public and Public-Private infrastructure collaborations.
- Imbedding Army Scientists and Engineers, using the Army Research Lab (ARL) open campus business model.

S&T Community

The Army S&T Strategy provides a unifying framework through which Army S&T laboratories and our industrial and academic partners are postured and empowered to mature disruptive technologies that ensure the operational overmatch for the Army and joint force. Demands of recent operations have required the Army's S&T Workforce to, in part, position itself to focus on near-term solutions. This dynamic, combined with emerging S&T developments, underscores the exigency that the Army's S&T Workforce, more routinely, consider the possible as well as the unthinkable to outpace unforeseen threats.

In particular, it is clear that the imperative to innovate and mature new technologies to meet capability needs has become even more critical to enabling the Army and joint

force than ever before. Efforts to evolve the technical workforce, are expected to facilitate critical technological developments for the future. The S&T enterprise must develop and retain a talented and high performing S&T workforce through:

- Developing senior S&T leaders to enable effective execution of S&T programs.
- Reshaping the existing technical workforce to meet emerging S&T challenges, dedicated to retraining current Army S&T professionals to prepare them to perform work in higher demand technical areas.
- Recruiting new personnel, and timely onboarding of S&T employees.
- Leveraging the best-and-brightest from across the Army S&T Enterprise, bringing together scientific professionals – Government, academic, and industrial – to address technical problems; these novel public-private partnerships are expected to enable rapid technology developments necessary to outpace emerging threats.

In addition to the roughly 12,000 scientists and engineers in the S&T enterprise, the Army Labs and Research, Development and Engineering Centers (RDECs) located throughout the United States are critical assets for the Army. With the committee's support, Army Labs and RDECs have been engaged with continual process improvements for years. Army Labs and RDECs have delivered key capabilities to the field in support of Operation Iraqi Freedom and Operation Enduring Freedom (Armor Kits for HMMWVs, Strykers, and MRAPs, IED solutions, Overwatch solutions).

Conclusion

For the imaginable future, the nation's landpower dominance will continue to heavily rely on significant S&T advances to ensure competitive advantage to the U.S. Army and the joint force. The Army S&T Strategy establishes a robust framework to efficiently pursue S&T advances that are essential to meeting the CSA's priorities concomitant with Joint Force operational goals articulated by the Secretary of Defense, thereby overcoming enduring technological challenges as well as emerging threats to agile and high-tempo land operations.

Dr. Thomas P. Russell
Deputy Assistant Secretary of the Army
(Research and Technology)
and
Army Chief Scientist

Dr. Thomas Russell was selected as the Deputy Assistant Secretary of the Army for Research and Technology and Army Chief Scientist in April 2016. He is responsible for policy and oversight of the Army's Research and Technology program, which spans 16 Laboratories and Research, Development and Engineering Centers, employs nearly 12,000 scientists and engineers, and has an annual budget that exceeds $2.4 billion.

In this position, Dr. Russell is charged with identifying, developing, and demonstrating technology options that inform and enable effective and affordable capabilities for the Soldier. His science and technology portfolio covers basic research to demonstrating component, subsystem, manufacturing technology, and technology system prototypes. It is executed by the Army's research, development and engineering laboratories and centers; academia; and industrial and international partners.

Prior to this assignment, Dr. Russell served as the Director of the U.S. Army Research Laboratory for three years. In this position, he led 3,000 military, civilian, and contractor employees providing the Army innovative science, technology, and analysis to enable full-spectrum operations with annual revenue exceeding $1 billion.

Prior to joining the Department of the Army, Dr. Russell served as Director of the Air Force Office of Scientific Research (AFOSR) from 2010–2013 where he oversaw the management of the Air Force's basic research investments. He led a team of 200 scientists, engineers, and administrators located in Arlington, VA, and in the foreign technology offices in London, Tokyo and Santiago, Chile. He managed the AFOSR's the investment portfolio that exceeded $500 million, and he transitioned the resulting discoveries to other components of the Air Force Research Laboratory, to defense industries, and to other federal agencies. Dr. Russell served as the Director of the Aerospace and Material Sciences Directorate within AFOSR where he was responsible for the Air Force's basic research program in aerospace, chemical, and material sciences.

From 1997-2006, Dr. Russell served with the Department of the Navy as the Director, Research, Development, Testing and Evaluation Directorate at the Naval Surface Warfare Center, Indian Head, MD; Section Head, High Energy Materials Section, Chemistry Division, Naval Research Laboratory, Washington, D.C., and as a research scientist at the Naval Research Laboratory, Washington, D.C. and at the Naval Surface Warfare Center, White Oak Laboratory, White Oak, MD.

Dr. Russell received a Ph.D. in chemistry, University of Delaware and a B.S. in chemistry, Muhlenberg College. He is the recipient of a Navy Superior Civilian Service award.

Dr. Russell was selected in 2006 to the Senior Executive Service and is Defense Acquisition Workforce Level III certified in Engineering. He is a member of the Army Acquisition Corps, the Joint Department of Defense/Department of Energy Munitions Technology Development Program, the Joint Insensitive Munitions Program, and the Joint Fuse Technology Program.

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HOUSE ARMED SERVICES COMMITTEE
EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

STATEMENT OF
REAR ADMIRAL DAVID J. HAHN, UNITED STATES NAVY
CHIEF OF NAVAL RESEARCH

BEFORE THE
EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE
OF THE
HOUSE ARMED SERVICES COMMITTEE
ON
THE FISCAL YEAR 2019 BUDGET REQUEST

MARCH 14, 2018

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HOUSE ARMED SERVICES COMMITTEE
EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

Introduction

Thank you for inviting me to speak with you about the investments the Department of the Navy (DoN) is making in Science and Technology (S&T) and to discuss how the President's FY 2019 Budget supports our Sailors and Marines. This critical funding is building the future Fleet and Force in support of our National Defense Strategy. The FY 2019 Budget requests $2.2 billion for Naval and Marine Corps S&T, and represents approximately 1.3 percent of the entire DoN Budget. As the Chief of Naval Research, I am responsible for the operations of the Naval Research Enterprise, which comprises more than 4,000 people in 23 locations, and more than 1,000 partners. This enterprise cannot succeed without strong Congressional support, for which I thank you.

Lessons From History

In 1946, the 79th Congress chartered the Office of Naval Research (ONR) to plan, foster, and encourage scientific research in support of Naval warfighting supremacy as a result of hard lessons learned during World War II. Throughout the ensuing decades, the U.S. Navy and Marine Corps capitalized on enduring and meaningful investments in early scientific research that offered technologically-superior solution space for evolving warfighting capability. While that model continues to provide value, the pace of technology development and global commoditization of advanced technologies necessitate a different response in a highly competitive environment with near peer adversaries. To put it simply, we are in a rapidly accelerating, technology-enabled competition for maritime superiority that we cannot afford to lose.

The New Naval Research Model

As then Secretary of the Navy James Forrestal said in 1947, "It is of the utmost importance to our national security that the Navy prosecute a vigorous and well-rounded program of research and development. To fail to do so in time of peace will surely result in this country entering another war with obsolete weapons and machines of warfare. And the tempo of modern war has reached the point where this Nation will probably never again have an opportunity to arm itself successfully after the start of hostilities…." From the time of ONR's inception through the end of

the Cold War, the vast majority of early research and development investment for our nation came from the federal government. Since the end of the Cold War, we have seen a significant shift in this accounting. Today's research and development ecosystem is global in nature and much more driven by investments in the commercial market. This marketplace is led by companies such as Alphabet, Intel, Tesla and Amazon, but also consists of large, medium and small companies across many sectors, non-profit organizations spanning numerous areas, and academic and government institutions around the world.

In response to these changes in the landscape, we have modified the way we do business to take better advantage of this evolving technology development ecosystem. We have broadened our partnership scope and have streamlined our processes to enable us to deliver capability at relevant speed. Our goals are to:

- Align naval research, development and acquisition to pursue technology-enabled warfighting capability
- Allocate resources to speed priority-aligned results to the warfighter
- Accelerate capability delivery by streamlining business execution and empowering people

Achieving these goals will yield greater lethality for our naval forces, enabled by innovation and speed -- speed in development, speed in decision-making and speed in business execution. Significantly, we realize that technology development unlinked to warfighting concepts and future battlefield environments can be wasted effort. Consequently, we are emphasizing our links to the operating forces through our naval laboratories by conducting more warfighter informed prototyping, experiments and demonstrations. This will assist in ensuring technology supports the warfighter and also help to resolve technical risk earlier in the development cycle.

We are aligned across the U.S. Navy and Marine Corps to be the first to field decisive capabilities such as Electric Weapons, Cross-Platform Networked Electromagnetic Maneuver Warfare, Artificial Intelligence, Swarming technology, and Autonomous Systems. We are also

taking every opportunity to partner with our Joint Force counterparts to learn and develop the cutting edge technologies that will provide our nation advantage.

Conclusion

The FY 2019 President's Budget request will enable us to move toward enhanced naval capabilities, promote more effective partnership between research and acquisition, and strengthen partnerships with the Army, Air Force, DARPA and other DoD research organizations – as well as performers outside the traditional defense research and development ecosystem. I invite you to tour the Naval Research Laboratory, and see firsthand the advances that are being developed right here in our Nation's Capital. I appreciate the opportunity to testify before you today and look forward to your questions on how we continue to maintain the U.S. Navy and Marine Corps' technological advantage.

Rear Admiral David J. Hahn
Chief of Naval Research
Director of Innovation, Technology Requirements and Test & Evaluation (OPNAV N94)

A native of Tampa, Florida, Rear Adm. David Hahn graduated from the U.S. Naval Academy with distinction in 1985, earning a Bachelor of Science in Mechanical Engineering. Additionally, he holds a Master of Business Administration from George Mason University and has completed the Massachusetts Institute of Technology Seminar XXI program in International Security Affairs.

Prior to command, he served at sea aboard USS Casimir Pulaski (SSBN 633), USS William H. Bates (SSN 680) and USS Springfield (SSN 761), deploying to the North Atlantic and Western Pacific, as well as conducting several strategic deterrent patrols.

Ashore, he served as flag lieutenant to superintendent, U.S. Naval Academy; squadron engineer, Submarine Development Squadron (SUBDEVRON) 12; action officer, Joint Staff in the Command, Control, Communications and Computers (C4) Directorate; and legislative fellow on the staff of U.S. Senator John Warner.

Hahn commanded the USS Pittsburgh (SSN 720) from September 2003 to January 2007. In command, he deployed to the Caribbean Sea and Pacific Ocean and conducted an Engineered Overhaul in Portsmouth, New Hampshire.

Since becoming an acquisition professional in 2007, he has served as Joint Test and Evaluation test director and program manager, Advanced Submarine Research and Development and served as major program manager, Submarine Combat and Weapon Control Systems program.

Hahn's first flag assignment was as the senior technical advisor to the deputy chief of Naval Operations for Information Warfare/director of Naval Intelligence (OPNAV N2/N6).In November of 2016, he became the 26th chief of Naval Research with concurrent flag responsibilities as director, Innovation Technology Requirements and Test & Evaluation (OPNAV N94).

Hahn has been awarded the Defense Superior Service Medal, Legion of Merit, Defense Meritorious Service Medal, the Meritorious Service Medal (three awards), the Navy and Marine Corps Commendation Medal (four awards), the Navy and Marine Corps Achievement Medal and various campaign and unit awards.

Updated: 29 November 2016

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HOUSE ARMED SERVICES COMMITTEE
SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES
U.S. HOUSE OF REPRESENTATIVES

DEPARTMENT OF THE AIR FORCE

PRESENTATION TO THE HOUSE ARMED SERVICES COMMITTEE
SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

U.S. HOUSE OF REPRESENTATIVES

14 MAR 2018

SUBJECT: Fiscal Year 2019 Air Force Science and Technology

STATEMENT OF: Mr. Jeffrey Stanley, SES
Deputy Assistant Secretary
(Science, Technology and Engineering)

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HOUSE ARMED SERVICES COMMITTEE
SUBCOMMITTEE EMERGING THREATS AND CAPABILITIES
U.S. HOUSE OF REPRESENTATIVES

INTRODUCTION

Madame Chairwoman, Members of the Subcommittee and Staff, I am pleased to have the opportunity to provide testimony on the Fiscal Year 2019 Air Force (AF) Science and Technology (S&T) Program and our efforts to innovatively and affordably respond to warfighter needs now, while simultaneously creating the force of the future.

To hedge against an uncertain future and ensure technological advantage, the Air Force continues to invest in a broad Science and Technology portfolio and other innovative efforts that will grow into future warfighting capabilities. Within the portfolio, we concentrate on game-changing technologies that can amplify many of the enduring attributes of airpower—speed, range, flexibility, and precision. Examples of Air Force game-changing technologies are: hypersonics, directed energy, autonomous systems and unmanned systems. Historically, the Air Force has maintained investment levels in basic and applied research related to longer-term national security challenges. Over the next several years, the Air Force plans to increase our research investment to maintain national security advantage in the air, space, and cyber domains. Challenges and threats to our national security are evolving rapidly – in some cases, our near-peer competitors are matching or exceeding our nation in gamechanging capabilities. The changes we are making will help ensure our technological advantage over our adversaries for the years to come.

The technologies the Air Force invests in are critically important, but the pace at which the Air Force innovates and responds is just as significant. Global competition has changed the speed at which the world around us operates. As indicated in the National Defense Strategy, "Success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts its way of fighting." The Air Force Posture Statement reinforces this understanding - it is not the country that innovates the best, but rather innovates and applies technology the fastest who will win the future war. Whether developed by us or leveraging efforts

from across the innovation enterprise such as DARPA, the Strategic Capabilities Office or industry, we must be able to seamlessly integrate new technology into our systems. The rapid pace of change will not relent and the Air Force must ensure it continues to provide the necessary capabilities to dominate the current fight, prepare for the future fight, and always ensure Airmen have the technological advantage over our adversaries.

AIR FORCE FISCAL YEAR 2019 S&T PROGRAM AND ASSOCIATED EFFORTS

As the Air Force budget request highlights, Air Force senior leaders are committed to science and technology and driving innovation across the enterprise. The Air Force Fiscal Year 2019 President's Budget request for S&T is approximately $2.6 billion. This is an increase of $62 million, or a 2.4% increase, from the Fiscal Year 2018 President's Budget request. The Air Force continues to emphasize research in hypersonics, directed energy weapons, autonomy and human machine teaming. The Air Force Fiscal Year 2019 President's Budget request also includes funding in Budget Activity 4 (Advanced Component Development and Prototypes) and in RDT&E Budget Activity 6 (Management Support) to support prototyping and experimentation efforts.

Developmental prototyping and experimentation allow the Air Force to quickly and efficiently explore the art of the possible and assess military utility for the warfighter. An example is the Light Attack Experiment, a live-fly event conducted at Holloman Air Force Base, New Mexico in August 2017 to assess the military utility of various non-developmental, light-attack platforms. This first phase of the experiment allowed the Air Force to assess the potential of these off-the-shelf, light attack aircraft to accomplish various permissive, close air support missions. The Air Force leveraged Other Transaction Authority (OTA) agreements, including industry cost-share agreements, to execute the experiment within *five months of authorization*. The collaborative environment we fostered throughout afforded industry and other stakeholders exceptional insight

into warfighter requirements. The Air Force plans to hold Phase II of the Light Attack Experiment in Fiscal Year 2018 as we develop the acquisition strategy for a potential procurement in the coming years.

GAMECHANGING TECHNOLOGIES

Hypersonics

We are assessing our investments in gamechanging technologies and concepts to ensure our technological advantage tomorrow and give our warfighters a future edge is critical. Although we have a long history in hypersonic research, the United States no longer enjoys preeminence and the Air Force recognizes the urgent need to increase investment in this technology. The Air Force continues to conduct research and development in partnership with the Defense Advanced Research Project Agency (DARPA) and National Aeronautics and Space Administration (NASA) on two S&T flight demonstration programs. The Hypersonic Air-breathing Weapon Concept (HAWC) project aims to develop and demonstrate critical technologies and attributes of an effective and affordable hypersonic cruise missile. The Tactical Boost Glide (TBG) project aims to develop and demonstrate technologies to enable future air-launched, tactical-range hypersonic boost glide systems.

The Air Force views hypersonics as a national issue and is leading a national network to push the boundaries and push to accelerate the possible fielding of this capability through two prototyping efforts. Air Launched Rapid Response Weapon (ARRW) will "push the art-of-the-possible" by leveraging the technical base established by the Air Force and DARPA partnership in hypersonics science and technology. Hypersonic Conventional Strike Capability (HCSW) is using mature technologies that have not yet been integrated to possibly deliver an air-launched delivery system.

Directed Energy

The Air Force S&T investment in directed energy, including high power microwave (HPM) and high energy laser (HEL) technologies, is to the point where distinctive and revolutionary capabilities can be prototyped for several Air Force and joint mission areas. The Air Force developed a Directed Energy Weapon (DEW) Flight Plan and is conducting a series of experiments and prototyping efforts to transition technologies from S&T to operational capability. Initial experimentation applications include forward base defense, aircraft self-protect, and precision strike. Experimentation and prototyping will examine how we operationalize this new class of weapons capability and align it with current capabilities and CONOPS. It will also examine other non-materiel changes, which may need to occur to capitalize on this technology.

Autonomy

Autonomy, artificial intelligence, machine learning and quantum computing have the potential to provide revolutionary enhancements to readiness and lethality as the Air Force prepares for increasingly complex, future operating environments. Advances in these areas provide significant improvements to decision-making speed and mission agility, posing new challenges to the adversary at a pace they cannot match. The Air Force is developing, maturing, and integrating technologies such as manned-unmanned teaming and machine learning decision-aids to enable airmen and intelligent machines to work together.

Building from our successful ground collision avoidance system, autonomy efforts are centered on improved safety, efficiency of operations, multi-system collaboration, and command and control. An example effort is the Actionable Intelligence Discovery and Exploitation (AIDE) tool, which can detect objects, caption intelligence imagery and is working to develop the ability to recommend intelligence, based on the Intelligence, Reconnaissance and Surveillance (ISR) analyst's learned preferences.

In order for the Air Force to continue to operate faster than our adversaries, operationalizing artificial intelligence is necessary; however, it is not without its challenges. First, current weapon systems are not architected to exploit the data being produced. In addition, the data produced is often not mined and tagged, which would enable efficient use. Lastly, machine learning and deep learning techniques associated with artificial intelligence require huge numbers of calculations to be made very quickly, which requires significant processing power. The Air Force is bringing a new focus to these areas and will be conducting an Artificial Intelligence Summit in May 2018 to gather leadership and determine how to effectively operationalize AI into our current Air Force systems.

Unmanned Air Systems

Stealth and precision enabled weapons changed the way the Air Force accomplished many of its missions in the 1980's and 1990's. The advent of Unmanned Air Systems (UAS) introduced a new class of air platforms in the last decade and enable an unrivaled ability to provide ISR on the battlefield. Digital engineering, the ability to design and build systems digitally coupled with advanced manufacturing, will enable a new generation of platforms which will revolutionize our ability to engage the enemy by developing attritable aircraft at a fraction of the cost of other platforms.

Additive and flexible manufacturing efforts from a network of national manufacturing partners are being combined with world-class, in-house Air Force laboratory resources to rapidly design, build, and field near-term limited-life unmanned air platforms as single assets or in 'swarms' of autonomous or manned/unmanned teams. These attritable aircraft can be used to impose high-cost responses from our adversaries and extend mission range. Open system architectures are being used to promote the use of artificial intelligence and also increase our options to rapidly deploy flight packages tailored to specific missions.

ENABLING & RELEVANT TECHNOLOGIES

While the Air Force has identified the above technology areas as gamechangers, there are many other efforts that are foundational to the Science and Technology portfolio.

Basic Research

Air Force basic research collaborates with universities and research centers from around the world and cuts across a broad portfolio of scientific disciplines. The Secretary of the Air Force S&T 2030 initiative is centered on building and reinforcing relationships between the Air Force scientific community and university, government, and industry partners. The Air Force will listen and learn from these relationships through a series of conversations and outreach events. The Air Force basic research portfolio will incorporate what is learned into new research and technology areas. Development of revolutionary capabilities requires broad investment in foundational science to generate new knowledge; Air Force scientists discover potential military utility in new science and research efforts and develop this understanding to change the art-of-the-possible. Gamechanging capabilities begin with foundational, cross-cutting and revolutionary basic research. Investment in Air Force basic research results in revolutionary breakthroughs that will continue to pay dividends in the years and decades to come.

Cyber

The execution of Air Force core missions to deliver airpower relies on the ability to effectively operate in cyberspace. The cyberspace domain is becoming increasingly contested and denied and the Air Force faces risks from malicious insiders, insecure supply chains, and increasingly sophisticated adversaries. Legacy warfighting systems were designed without taking this threat into consideration and are populated with complex systems and Systems of Systems (SOS) that mature independently, stressing the ability to thoroughly test and integrate cyber capabilities.

The Air Force S&T cyber investments include many areas to assure communications across domains and counter global threats to mission performance (spectrum congestion and jamming), increase capacity over longer range air-to-air with military-grade security, and maintain or increase available bandwidth through dynamic spectrum access. The Air Force is enhancing cyber resiliency through an effective mix of redundancy, diversity, and distributed functionality that leverages advances in virtualization and cloud technologies. Efforts such as the Cyber Grand Challenge, executed in collaboration with DARPA, have informed Air Force investments in counter cyber operations such as defensive autonomic response. Air Force S&T efforts in mission assurance are pursuing survivability and freedom of action in contested and denied environments through enhanced cyber situational awareness for air, space, and cyber commanders.

Assured Communications

The renewed emphasis on the Nuclear Command & Control and Communications (NC3) mission has the Air Force conducting a strategic S&T initiative focused on survivable airborne communications that are resilient and responsive in nuclear environments. The initiative will explore technologies in the following areas: waveforms, underutilized frequencies and scintillated environment models to leverage new spectral research intended for satellite communications; enhanced beyond-line-of-sight communications technologies, including wideband HF communications; modeling and simulation to characterize communications performance using high fidelity models for end-to-end NC3 system test and evaluation; and network management and situation awareness required for assured nuclear command and control.

Space

The Air Force confronts a broad spectrum of space challenges that extends from unintentional environmental and physical hazards to intentional threats, some of which might be

constructed to escape easy detection and attribution. The Air Force's S&T investment includes ground-based optical Space Situational Awareness (SSA). The Air Force has two unique 3.5 meter class telescopes to conduct research in characterizing space objects in low earth orbits up to geostationary orbits and to support various customers in providing near real-time data on such space objects. One of the systems is located at the Starfire Optical Range (SOR) on Kirtland Air Force Base, New Mexico and the other is located at the Maui Space Surveillance System (MSSS) on the island of Maui, Hawaii. These sites are complementary SSA sites, technically and geographically situated in different atmospheric conditions, providing critical data to our space warfighters on the health and status of many satellites.

The Air Force SSA S&T program also supports the National Space Defense Center by integrating key astrodynamics, space order of battle and indications and warning tools. The S&T developed Advanced Research Collaborative and Application Development Environment (ARCADE) provides a path for future technologies to affordably reach the NSDC. Other S&T efforts leverage our space environment tools and expertise to enable the rapid attribution of environmental effects on DoD satellites and services – a key step in identifying hostile activities. SSA S&T investments help provide a more complete picture of a space vehicle's operating environment, develop and evaluate operations plans, and exercise improved command and control over space forces to confront tomorrow's challenges in space.

The Air Force seeks to explore and mature a number of space resilience technologies in a relevant environment through on-orbit space experimentation. The ESPA Augmented GEO Laboratory Experiment (EAGLE) project is an AFRL flight experiment that will demonstrate enhanced capabilities in space system anomaly resolution and the capability to supplement ground based space situational awareness assets from a geosynchronous platform. EAGLE is scheduled for a Spring 2018 launch date and will inform future acquisition and operational capabilities. The Air

Force also continues development of the Navigation Technology Satellite-3 (NTS-3), which aims to demonstrate a range of technologies for potential inclusion in future GPS satellites or potential augmentation of GPS, such as hosted Satellite Navigation (SatNav) payloads on other DoD, commercial, or international spacecraft. Launch of NTS-3 is currently projected for 2022 with a planned one-year on-orbit experiment period.

The Air Force is investing in propulsion technologies that will greatly increase the flexibility and resiliency of military satellites. S&T includes: flight programs; advanced electric and chemical propulsion; modeling, simulation, and analysis; and plume phenomenology and signatures. The Air Force has transitioned spacecraft propulsion technologies to most of the nation's National Security Space systems since the 1980s. The latest system to fly Air Force spacecraft propulsion technology (Hall Effect Thrusters) is the Advance Extremely High Frequency (AEHF) satellite. The Air Force has matured Hall Effect Thrusters and is now engaging in research into multimode thrusters in the form of Field Reverse Configuration thrusters. These multimode thrusters are capable of highly efficient, low thrust operations when needed to do station keeping while simultaneously being able to provide high thrust when needed to maneuver quickly, all using a single propellant.

Position, Navigation, and Timing

The Air Force is emphasizing S&T efforts in Position, Navigation and Timing (PNT) to improve the robustness of military Global Positioning System (GPS) receivers, as well as develop non-GPS based alternatives including: exploitation of other satellite navigation constellations, use of new signals of opportunity, and incorporation of additional sensors such as star trackers and terrain viewing optical systems. The Air Force is also partnered with DARPA on inertial and clock size, weight, power, and cost (SWaP-C) advances via a variety of technological approaches and in starting a new very low frequency (VLF) terrestrial beacon based navigation and timing effort.

Ensuring PNT is critical to our nation's security and remains an area of emphasis, especially for the Air Force.

Nanotechnology

Nanoscale structures promise revolutionary advances in a wide range of Air Force and DoD applications and platforms by delivering materials, coatings, devices and sensors with new and novel performance. Air Force investments in this gamechanging technology include ultra-small, customized munitions enabled by the precise control of components at the nanoscale. New designs of energetic material, casing and solid propellant will enable higher energy and smaller weapons, reducing size and weight while delivering the same or greater effect. Nanotechnology enabled multifunctional and adaptive structural materials in development will harden electronics from electromagnetic threats and maintain structural performance during hypersonic conditions. Air Force nanotechnology will underpin many new Air Force capabilities by reducing size and weight and increasing power and strength.

Manufacturing Technologies

The Air Force's Manufacturing Technology program is focused on promoting technologies for an agile, next generation manufacturing industrial base with strategic benefits in efficiency, affordability, and capabilities in Air Force warfighting products. The program strategically aligns key agile manufacturing objectives including: 1) moving manufacturing considerations earlier in the design cycle to reduce acquisition cost and risk; 2) enabling seamless lifecycle management through an integrated digital thread to document and improve process control, optimization, and manufacturing agility; 3) integrating the industrial base enterprise to predict, identify, and react to supply chain issues; and 4) creating the factory of the future with flexible, smart machine cells and assembly processes that are efficient even at low volume production. Mastering the art of designing and manufacturing for attritability—cheap enough to take risk, expensive enough to reuse,

dangerous enough to kill the enemy if ignored—will be key to imposing cost on adversaries while also keeping future Airmen safe in a contested fight.

EXPERIMENTATION AND PROTOTYPING

The Air Force continues to drive toward strategic agility. The Vice Chief of Staff of the Air Force chairs a Capability Development Council (CDC) that recognizes the Air Force's highest priority operational challenges and opportunities and aligns them with strategy, planning, programming, requirements and acquisition activities across the enterprise. The CDC represents our new way of doing business – leveraging innovation, collaboration and teamwork across functional and organizational boundaries to provide balanced, technically sound, decision-quality options to inform senior leadership direction. The CDC directs experimentation campaigns that create an environment where our airmen can take smart risks when exploring innovative ideas and technology.

Experimentation provides the ability to rapidly explore a wide range of innovative materiel and non-materiel solution options - an approach that enables unfettered exploration of alternative concepts. The Air Force has several on-going experimentation campaigns. The Air Force is preparing for Phase II of the Light Attack Experiment. Phase II will experiment with maintenance, data networking and sensors with the two most promising light attack aircraft — the AT-6 Wolverine and the A-29 Super Tucano, and allow us to gather the data needed for a rapid procurement. It will examine logistics and maintenance requirements, weapons and sensor issues, training syllabus validity, networking and future interoperability with partner forces. The Air Force will also experiment with rapidly building and operating an exportable, affordable network to enable aircraft to communicate with joint and multi-national forces, as well as command and control nodes.

This effort to find a lower cost and exportable aircraft for permissive environments is directly in line with the National Defense Strategy and the Air Force is committed to maintaining the momentum gained by the success of Phase I of the experiment.

Prototyping is also a valuable tool for the Air Force. It enables the Air Force to evaluate the design and performance of new concepts and technologies. The Air Force has recognized that engaging operational users intimately involved in need analysis, solution conceptualization, and prototype development enables delivery of a suitable prototype with all the right attributes to satisfy the user need. Furthermore, a rapid spiral development process that incorporates experimentation and prototyping allows the design to evolve quickly based on lessons learned during operations.

In addition to the hypersonics and directed energy prototyping efforts mentioned earlier, the Air Force is also making strides with prototyping. Efforts such include the Low Cost Attritable Aircraft Technology (LCAAT) effort, which will demonstrate manned-unmanned teaming with low-cost unmanned aircraft and the Global Lightning effort, which leverages commercial space internet networks to a global, low-latency, high bandwidth communications network. The benefits of prototyping are paying off, as we accelerate the transition from tech concept to military utility at a pace that is relevant to today's ever changing environment.

SUCCESS STORIES

While we look ahead to what's next, we also celebrate the recent accomplishments and breakthroughs of the Air Force Science and Technology community. The Air Force has seen progress on a broad range of technology fronts. Some of our highlights include:

- *Roll-out Solar Array (ROSA)*: A flight experiment on the International Space Station achieved 100% of its science objectives. The array consists of a 15x15 foot photo-voltaic

wing, which is unfurled by two high-strain composite booms. Developed through a Small Business Innovative Research (SBIR) project collaboration, the array reduces mass by 20% and packaged volume by 75% over rigid panel arrays. ROSA transition of technology to business partners is in progress.

- *Special Tactics Tactical Assault Kit (ST-TAK):* A geospatial application that supported Hurricane Harvey and Hurricane Irma Disaster Response efforts. Air Force personnel collaborated with the Department of Homeland Security and numerous DoD organizations to provide the ST-TAK tool, which enabled information sharing, mapping capabilities and server connectivity for rescue workers via cell phones. ST-TAK enabled better coordination of relief efforts during peacetime disaster response efforts in Texas and Florida.
- *Automatic Ground Collision Avoidance System (Auto-GCAS)* –Auto-GCAS technology prevents loss of aircraft and, more importantly, saves lives. In Spring 2017, the Auto-GCAS system activated during an F-16 training mission; both pilots onboard passed out due to G-force induced loss of consciousness (G-LOC) during a 9G maneuver. Auto-GCAS engaged, steered the aircraft away from nearby high terrain and the aircraft was safely recovered. Since fielding in Sep 2014, Auto-GCAS has saved 6 aircraft and 7 pilots. In Dec 2017, the F-35 Configuration Steering Board approved early implementation of Auto-GCAS on the F-35 for all variants; detailed engineering development will begin in 2018.
- *3-D Printed Turbine Engine Breakthrough:* The Air Force completed successful demonstration of an additively manufactured turbine that can drastically reduce the timeline of the development cycle. The turbine consisted of a super-alloy created using direct metal laser sintering. The part achieved full power in an otherwise stock jet engine. This is the first time that full operating power and speed were achieved using a printed turbine. The approach reduces the time from design to demonstration from two years to months.

WORLD CLASS WORKFORCE

The global competition for technology and the pace of technology development directly translates to the workforce. A world class workforce for the Air Force science, technology and engineering community continues to be our most important requirement. The demand for technical talent is quickly outpacing degree production in the US and competition for talent is at an all-time high. The Air Force recognizes continued technological superiority depends on the technical talent and innovative spirit of our workforce. In order to maintain an agile science, technology, engineering and mathematics (STEM) workforce, two aspects guide investments and collaborative energy this year: attracting and inspiring individuals to Air Force STEM careers and recruiting, retaining and developing the STEM workforce.

Attracting and Inspiring STEM Talent

The Air Force executes a STEM Outreach Program to attract and inspire technical talent to choose an Air Force career. The Air Force is a significant contributor to the Nation's strategy to establish greater economic and military security by educating and inspiring more scientists, engineers and innovators. A STEM trained and STEM literate workforce enables the innovation to make game-changing technologies a reality. The Air Force is leveraging industry and other government agencies, promoting diversity, and measuring results to ensure a successful and effective STEM Outreach Program.

The Air Force executes many STEM programs designed to engage students in STEM events from a young age. One such activity is the *StellarXplorers* competition, which brings teams of high school students together to learn the engineering design process using Analytical Graphics, Inc.'s (AGI) Systems Tool Kit (STK). The competition employs computer simulations for orbit generation and propagation, computer-aided system design, system performance assessment, and budgetary constraints. The program has seen a steady increase in participation as it flourishes into a national

level program. StellarXplorers has grown from 27 teams in 2015 to 180 teams in 2017, including 31 states and 3 overseas locations. In another STEM workforce activity, the Air Force and Navy funded a new Cyber and Electronic Warfare (EW) Reserve Officers' Training Corps (ROTC) effort, which allows cadets to get their security clearances while in school so they can work on real-world research projects for the Air Force and other Services. This effort helps develop the new cadre of Cyber/EW officers for the DoD. The program will grow from 55 initial Air Force, Army and Navy cadets / midshipmen in 2016 to over 200 in 2018. This effort proactively builds a talent pipeline from which the services can pull. Our need for the world's best scientists, technologists, engineers, and mathematicians has never been higher and will continue to increase.

Recruiting, Retaining and Developing the STEM Workforce

The Air Force's ability to recruit, retain and develop the STEM workforce is vital toward building the future Air Force; Congress has been greatly supportive of these efforts. The National Defense Authorization Acts of the past several years have provided additional personnel authorities to the S&T community. Specifically, the addition of direct hire authority for candidates with bachelor degrees has been extremely useful in hiring qualified scientists and engineers in less than half the time of traditional hiring methods. The Air Force continues efforts to fully implement all of the personnel authorities provided specifically to our community by Congress.

The Laboratory Personnel Demonstration Project continues to provide the Air Force Research Laboratory a more responsive and flexible personnel system through direct hire authorities, broad banding, the contribution based pay system, simplified job classification, developmental opportunities, voluntary emeritus corps, among other unique workforce shaping tools. These authorities have enabled the Laboratory to successfully attract and retain high quality scientists and engineers.

LABORATORY INFRASTRUCTURE

S&T infrastructure is an important component to support innovation and force modernization. Thanks to the approval of the Congress, progress is being made on a new Space Vehicles Component Development Lab at the Air Force Research Laboratory Space Vehicles Directorate in Kirtland, NM. The project will break ground Summer 2018, providing the ability for space vehicles component development including four light laboratories, two medium laboratories, and class 1,000 clean rooms required for space vehicle research, development, and experiments. This new facility will consolidate 11 separate S&T infrastructures on Kirtland Air Force Base, New Mexico, increasing the effectiveness and efficiency of work accomplished by the directorate.

In Fiscal Year 2017, Congress approved the construction of an Advanced Munitions Technology Complex on Eglin Air Force Base, Florida. Designs for the facility are now complete and target completion for this project is 2021. This laboratory is integral to support research and development of sub-scale high speed munitions requiring advanced energetics containing nano and conventional materials. This laboratory will fill a need for the Air Force and the entire DoD as it will be capable of handling and using nano explosive powders or advanced energetics that use nano materials, a capability which does not currently exist in the U.S. today.

Not only has S&T infrastructure received Congressional support in the MILCON process, special Congressional authorities provided to the Laboratory Commander to conduct minor infrastructure projects, known as the "Section 219" authority, have enabled rapid improvements to S&T infrastructure. Through this authority, the Air Force is funding multiple capability-enhancing infrastructure projects such as an ultrashort pulse laser laboratory (USPL), which will be the only Air Force Petawatt-class USPL for mid and far infrared lasers, expanding research capabilities and providing our scientists and engineers with an indoor range testing area; a deployable structures

laboratory (DeSEL), which will enable realistic testing of deployable space structures; as well as upgrades to our Missile Assessment Center, a critical laser technology demonstration area.

CONCLUSION

Chairman, Members of the Subcommittee and Staff, thank you again for the opportunity to testify today on the Air Force's expansive S&T program, planned and executed with capability development and strategic agility at the forefront. Your support continues to allow the Air Force to maximize the impact of our robust S&T program (gamechanging, enabling, relevant, and rapid technologies), champion efforts in experimentation and prototyping, and leverage the contributions of our entire world class workforce and infrastructure.

Jeffrey H. Stanley

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

Mr. Stanley joined federal service in 1985 under Naval Air Systems Command where he worked a variety of fixed and rotary-wing programs. In 1987, he moved to Wright- Patterson AFB, Ohio, where he held numerous technical and leadership positions at the Air Force Research Laboratory, Headquarters AFMC and Aeronautical Systems Center. He has joint experience with the Joint Strike Fighter and assignments in both the space and intelligence arenas. While serving as the Deputy Director, Intelligence, Surveillance, Reconnaissance and Requirements Directorate, Headquarters Air Force Materiel Command, he enabled AFMC to deliver war-winning capabilities through life-cycle capabilities planning, technology development and transition, intelligence integration and acquisition support. He most recently served as the Associate Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering.

EDUCATION
1985 Bachelor's degree in electrical engineering, Ohio University, Athens
1995 Master's degree in business administration, University of Dayton, Dayton, Ohio
1996 Air War College, Air University, Montgomery, Ala.
2001 Defense Systems Management College, Fort Belvoir, Va.
2002 Defense Leadership and Management Program

ASSIGNMENTS
1. October 1985 - August 1987, electronics engineer, Naval Avionics Center, Indianapolis
2. August 1987 - July 1989, avionics technical director, Advanced Launch System, matrix support to Space and Missile Center, Wright Research and Development Center, Wright-Patterson AFB, Ohio
3. July 1989 - December 1994, electronics engineer, Avionics Directorate, Wright Laboratory, Wright-Patterson AFB, Ohio
4. January 1994 - September 1996, IPT Lead, Joint Advanced Strike Technology Program, Arlington, Va., dedicated matrix support from Avionics Directorate, Wright Research and Development Center, Wright-Patterson AFB, Ohio
5. October 1996 - January 1998, Deputy, Analysis and Integration IPT, Joint Strike Fighter Program Office, Arlington, Va., dedicated matrix support from Avionics Directorate, Air Force Research Laboratory, Wright-Patterson AFB, Ohio
6. January 1998 - November 2000, Onboard Systems IPT Lead, Joint Strike Fighter Program Office, Arlington, Va.
7. November 2000 - September 2001, Analysis and Integration IPT Lead, Joint Strike Fighter Program Office, Arlington, Va.
8. September 2001 - January 2002, student, Defense Systems Management College, Fort Belvoir, Va.
9. January 2002 - July 2002, Air Force Science and Technology Lead, Joint Strike Fighter Program Office, Air Force Research Laboratory, Wright-Patterson AFB, Ohio
10. July 2002 - January 2003, Principal Plans and Programs engineer, Acquisition Center of Excellence, Headquarters Air Force Materiel Command, collocated from Headquarters Air Force Research

Laboratory, Wright- Patterson AFB, Ohio
11. January 2003 - August 2005, Deputy, Acquisition Support Division, Capabilities Integration Directorate, Headquarters AFMC, Wright-Patterson AFB, Ohio
12. August 2005 - November 2008, Deputy Director, 823rd Aeronautical Systems Group, Aeronautical Systems Center, Wright-Patterson AFB, Ohio
13. November 2008 - July 2009, Director, SIGINT Programs, ISR Directorate, Wright-Patterson AFB, Ohio
14. July 2009 - March 2011, Deputy Chief, Special Operations Forces and Personnel Recovery Division, Aeronautical Systems Center, Wright-Patterson AFB, Ohio
15. March 2011 - December 2011, Chief, Special Operations Forces and Personnel Recovery Division, Warner Robins Air Logistics Center, Robins AFB, Ga.
16. December 2011 - January 2015, Deputy Director, ISR and Requirements Directorate, Headquarters AFMC, Wright-Patterson AFB, Ohio
17. January 2015 - present, Associate Deputy Assistant Secretary (Science, Technology & Engineering), Office of the Assistant Secretary of the Air Force for Acquisition, the Pentagon, Washington, D.C.
18. March 2017 - present, Deputy Assistant Secretary (Science, Technology and Engineering), Office of the Assistant Secretary of the Air Force for Acquisition, the Pentagon, Washington, D.C.

AWARDS AND HONORS
1986 Outstanding Engineer Award, Naval Avionics Center
1990, 1992, 1993, 1994 Technology Transition Award, Avionics Laboratory
1993, 1994, 1995 Customer Support Award, Avionics Laboratory
1996 Program Manager of the Year, Avionics Laboratory
2000 Directors Award, Sensors Directorate
2002 Exceptional Civilian Service Award
Numerous Special Act/Service Awards

PROFESSIONAL CERTIFICATIONS
Systems Planning, Research, Development and Engineering, Level III
Acquisition Logistics, Level I
Program Management, Level III

(Current as of March 2017)

WITNESS RESPONSES TO QUESTIONS ASKED DURING THE HEARING

MARCH 14, 2018

RESPONSES TO QUESTIONS SUBMITTED BY MR. LAMBORN

Ms. MILLER. Although the legislation does require USD (A&S) to establish "an appropriate leadership structure and office within which a cadre of Intellectual Property Experts shall be managed," the Department is still in the planning process, and has not yet formed such an entity. The establishment of this office has been deferred while the Department's leadership addresses the creation of the Under Secretaries for Research & Engineering and Acquisition and Sustainment. [See page 18.]

Ms. MILLER. The pilot authority of Sec. 1710 of the FY18 NDAA will allow organizations across the Department to easily leverage SBIR and STTR developed technologies, supplies, or services. In implementing the pilot, we first coordinated with Services and Agencies to identify where multiple award agreements were already in use to support SBIR and STTR technology development and transition. Our guidance for implementation of a DOD-wide pilot was modelled on these programs to allow incorporation of lessons from the field. In early June, implementation instructions were distributed throughout the Department to encourage additional use of multiple award contracts to covered small business concerns for the purchase of technologies, supplies, or services developed in the SBIR or STTR Program. In addition to the Sec. 1710 pilot program, the SBIR and STTR programs have multiple tools available to support technology transition. These include Phase III of the SBIR and STTR programs where no SBIR funds are provided by government or prime contractors to complete critical development or testing of these technologies in preparation for transition. The Rapid Innovation Fund (RIF) program provides another avenue to enable transition of technologies from the SBIR and STTR programs to meet warfighter needs. Additionally, the Commercialization Readiness Program (CRP) is used the provided dedicated support to improve transition outcomes for many technologies. Finally, the department was also successful in the use of the Phase Flexibility pilot authority (also known as Direct to Phase II), which unfortunately expired at the end of FY17. Phase flexibility provided the ability to shorten the development cycle for critical technology solutions. In today's environment, rapid delivery of technical capabilities to the warfighter is critical. This authority has shortened the development time for technologies to transition to Phase III funding. This encourages companies with more mature technologies to participate in the program, further enhancing the technical solutions available to DOD. This provision should be reauthorized and made a permanent part of the program. The third phase of the SBIR and STTR programs, referred to as Phase III or the "commercialization phase", as well as the Rapid Innovation Fund (RIF) program provide resources that are critical for the successful transition of new technologies into the Department. While not every research project can (or should) transition, for those technologies that are ready and provide needed capabilities, the additional funding available through Phase III and RIF allows further maturation of technologies as well as needed testing and evaluation. [See page 18.]

QUESTIONS SUBMITTED BY MEMBERS POST HEARING

MARCH 14, 2018

QUESTIONS SUBMITTED BY MR. LARSEN

Mr. LARSEN. Please provide what percentage of the topline request S&T has compromised (6.1–6.3) for FY19 and the previous four fiscal years.

Ms. MILLER. Fiscal Year 2019: 2.0 percent Fiscal Year 2018: 2.1 percent Fiscal Year 2017: 2.0 percent Fiscal Year 2016: 2.1 percent Fiscal Year 2015: 2.1 percent

Mr. LARSEN. During the hearing, we spoke of the need to expand on the successful Robotarium concept (open access, collaboration with NSF, partnership with academia, swarms of autonomous vehicles).

What would the total cost to the ONR be (assuming a 50/50 cost share with NSF) be to establish a Multi-Domain Robotarium incorporating UUVs, USVs, and UASs, and what would the value be of such an initiative?

Admiral HAHN. The Robotarium concept presents an opportunity for researchers to conduct experiments with distributed and interconnected autonomous systems, which are expected to play an increasingly important role in future defense operations. These types of systems may enable new capabilities across a wide range of defense applications including tactical sensing and prediction of ocean and littoral environments, surveillance, reconnaissance/search, mine countermeasures, force protection, logistics, and humanitarian and expeditionary operations. For the defense research enterprise, the Robotarium addresses an important challenge of scaling up innovation and reducing the cost of entry in order to accelerate advances in technology and fundamental understanding of scalable, collaborative autonomous systems. Rather than having individual researchers or institutions invest time and resources on hardware development and maintenance, the Robotarium provides a remotely accessible multi-robotic testbed. This enables researchers to upload new software and automatically conduct experiments to test and compare methods, gain new knowledge, and advance robotics technology. The total potential cost depends on the scale and capability of the completed work and experimentation space. A range for the endeavor would be $2–10 million depending on the size, scope and complexity. One of the big challenges that will drive the costs is the extent of investment to simulate the effects of genuine undersea mission, sensor, and communications payloads such as sonar and acoustic communications. If more realistic sized vehicles that are used by the military and realistic conditions are needed, the cost could easily increase an order of magnitude. Additionally, operating costs are not included in this estimate.

QUESTIONS SUBMITTED BY MS. SPEIER

Ms. SPEIER. The Administration's FY 19 budget proposes to reduce funding for the Defense Science and Technology (S&T) program by $350 million or approximately 2.5 percent from FY 2017 enacted. Requested funding is also below what is proposed in both the House and Senate FY 18 Defense Appropriations bills. Given that a priority of the National Defense Strategy is to maintain the Department technological advantage, it is puzzling why the budget requests fewer resources for the Defense S&T program. As is stated in FY 19 budget documents, the Defense S&T program "invests and develops capabilities that advance the technical superiority of the U.S. military to counter new and emerging threats." Please explain the rational for requesting fewer resources for Defense S&T given that the Department received significant relief from the budget caps.

Ms. MILLER. The Department's President's Budget (PB) request for S&T (includes Base, OCO, and Amendments) has grown as compared to the previous year's PB request. The PB request for FY 2017 was $12.7B, FY 2018 was $13.2B, and FY 2019 was $13.7B. The growth between FY 2017 and FY 2018 is 4.6%, and between FY 2018 and FY 2019 is 3.2%. The S&T request for FY 2017–FY 2019 has been constant at 2% of the DOD PB Requested Topline (includes Base, OCO, and Amendments). The DOD PB Request represents the best balance of requirements against resources. It should be noted that efforts in other RDT&E lines (i.e., 6.4–6.7) also contribute to the ability to maintain the Department's technological advantage.

QUESTION SUBMITTED BY MR. LAMBORN

Mr. LAMBORN. Regarding DIUx, how does DOD plan to improve outreach to innovative companies outside of the Silicon Valley, Boston, and Austin?

Ms. MILLER. Since June 2016, more than 650 companies from 43 states have submitted proposals in response to DIUx's solicitations. Outreach is key, and DIUx has a multi-prong strategy for nationwide outreach to key groups in order to feature streamlined business processes and the DOD challenges. Targeted efforts for engagement include: presentations/panel participation at key national technology/innovation events; placement and interviews in targeted trade and mainstream publications; outreach to incubators, accelerators, and venture capitalists across the country; coordination and visits to State economic development entities including local chambers of commerce, civic associations, and SBIR/STTR entities on local bases; connection to the citizen soldiers, sailors, airmen, and Marines who serve as technology industry leaders and entrepreneurs when they're not on duty as reservists/National Guard.

QUESTIONS SUBMITTED BY MR. HICE

Mr. HICE. Dr. Walker, in looking at the DOD's research and development plan, do you believe that our universities could be involved in long-term research and building up the bench strength of scientists and engineers for American hypersonics technical know-how? How do you engage with the university community to address the long-term research and skilled workforce needs in hypersonics?

Dr. WALKER. Universities cannot only be involved in strengthening our nation's hypersonics workforce, they provide a critical role in establishing and maintaining a robust pipeline of qualified and energized young scientists and engineers to support one of DOD's top modernization priorities. There are multiple opportunities to engage and align university resources with DOD needs. The first is through Multidisciplinary University Research Initiatives (MURI), executed by the DOD's service research offices—such the Air Force Office of Scientific Research (AFOSR), Office of Naval Research (ONR), and Army Research Office (ARO). MURIs can be focused on hypersonic technology development areas such as aerodynamics and aeroheating; structures and materials; airbreathing and rocket propulsion; guidance, navigation, and control; and rapid/robust design, integration, optimization, and uncertainty. Secondly, DARPA engages universities through its basic research programs through its Defense Sciences Office (DSO), that address technology development areas such as basic material science for hypersonic systems. Finally, DARPA and the services can work together in sponsoring hypersonic flight research experiments that engage the university community and offer a unique opportunity to rapidly build experience in our young workforce. This is exemplified by the DARPA/AFOSR hypersonic Boundary Layer Transition (BoLT) project which is sponsoring two university-led teams to conduct ground and flight experiments to advance our fundamental understanding of boundary layer transition physics for a new class of hypersonic geometry.

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