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ACCELERATING NEW TECHNOLOGIES TO MEET EMERGING THREATS

HEARING

BEFORE THE

SUBCOMMITTEE ON
EMERGING THREATS AND CAPABILITIES

OF THE

COMMITTEE ON ARMED SERVICES
UNITED STATES SENATE

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SECOND SESSION

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ACCELERATING NEW TECHNOLOGIES TO MEET EMERGING THREATS

WEDNESDAY, APRIL 18, 2018

UNITED STATES SENATE,
SUBCOMMITTEE ON EMERGING
THREATS AND CAPABILITIES,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:32 p.m. in Room SR–232A, Russell Senate Office Building, Senator Joni Ernst (chairman of the subcommittee) presiding.

Committee members present: Senators Ernst, Fischer, Perdue, Heinrich, and Peters.

OPENING STATEMENT OF SENATOR JONI ERNST

Senator ERNST. Good afternoon. The Subcommittee on Emerging Threats and Capabilities meets today to receive testimony from Dr. Michael Griffin, Under Secretary of Defense for Research and Engineering, on accelerating new technologies to meet emerging threats.

Welcome, Secretary. It is good to have you here.

The National Defense Strategy [NDS] acknowledges that our increasingly complex security environment is defined by rapid technological advancements, which have the potential to change the very character of war. These technologies include advanced computing, Big Data analytics, artificial intelligence, autonomy, robotics, directed energy, hypersonics, and biotechnology.

Moreover, their development is increasingly dispersed, expanding both to near-peer competitors and other actors with the means to use these technologies against our warfighters.

These technologies also represent major opportunities for our own forces, and innovation has always been a major strength of the Department of Defense's [DOD] research and engineering enterprise, which includes the DOD laboratories and organizations like DARPA and the Strategic Capabilities Office.

However, getting these technologies in the hands of our warfighters can sometimes be challenging for the Department of Defense, which has struggled to bridge the so-called "valley of death" for new technologies. This valley refers to the space between the research and engineering community and the acquisition community, which are responsible for fielding operational systems.

In his confirmation hearing, Secretary Griffin testified that this transition is the "hardest problem we have." I will look to Secretary Griffin to understand how he will use his own newly established position to help bridge this gap.

The fielding of these critical new technologies contained within the National Defense Strategy demands urgent attention and new approaches to ensure that our forces are postured to fight and win. Broadly, I look to Secretary Griffin to see how he plans to fulfill his charge as chief technology officer for the Department of Defense to sustain and expand U.S. technological superiority in the future.

Specifically, I hope to understand specific examples of research and technology efforts aimed at ensuring our forces are organized, trained, and equipped to succeed in our increasingly complex environment.

Opening comments, Senator Heinrich?

STATEMENT OF SENATOR MARTIN HEINRICH

Senator HEINRICH. Let me start by thanking Senator Ernst for holding this important hearing on technology transfer and the ways that we can move technologies and systems more rapidly into the hands of our operational forces.

Welcome, Secretary. It has been almost 2 months since you were confirmed for this job, so you may not have fixed everything yet, but we hope that you are making good progress.

I hope that today's hearing will help us better understand the barriers to the smooth transition of next-generation technologies, whether they are from the funding point of view, legal, regulatory, cultural, or other things that we have not thought about.

We know that we are in a race to build future technologies and systems that our military will need to execute its missions against peer threats as well as emerging threats. We also know that the United States is still home to the world's most innovative companies, small businesses, research universities, and government labs.

The State of New Mexico alone is proud to host two national security laboratories, the Air Force Research Laboratory, White Sands Missile Range, and a number of high-tech small businesses, each employing some of the best and brightest minds in the country.

Yet, one of our Nation's biggest challenges remains in determining how we can best connect those innovators to the real current and future challenges facing our military, and how to move the best new technologies into the hands of our warfighters as quickly and effectively as possible.

All of the members of this committee have heard frustrating stories of companies with great ideas or universities and government labs performing cutting-edge research that cannot seem to get traction and fight through the Pentagon's arcane and bureaucratic procurement and funding processes, only to get stuck in that valley of death that Senator Ernst spoke about.

This committee has taken a number of steps to help transition technologies, including strengthening science and technology prototyping efforts; emphasizing weapons of the future, like directed energy; supporting the Small Business Innovation Research program; and trying to cut back on the red tape and bureaucracy that slows this process. But I certainly believe we can do more.

Tackling the issues that prevent the transition of technologies is a key emphasis of your work, Dr. Griffin, and you have an excellent opportunity to do so as our Nation's Under Secretary for Research and Engineering.

Dr. Griffin, I hope we can hear today your early estimate of the biggest challenges to effectively transition technology and learn what steps you are beginning to take to address them and how we can help. I also look forward to hearing what hurdles you are encountering in terms of setting up your organization and staffing in the Pentagon, and deconflicting authorities with the services and other parts of the Pentagon.

Finally, I hope to learn what steps this committee and other committees in Congress can take to assist in these efforts. Our military's technological edge may not depend solely on your success, but your success can greatly alter the ability of our military to stay ahead of our adversaries.

I look forward to your testimony and learning more about how we can help.

Senator ERNST. Go ahead, Secretary. Thank you.

STATEMENT OF HON. MICHAEL D. GRIFFIN, UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

Dr. GRIFFIN. Chairwoman Ernst, Ranking Member Heinrich, Senator Peters, Senator Fischer, Senator Perdue, thank you for being here. I really appreciate this opportunity to talk to you about these issues. I am going to offer a very brief opening statement and ask that you submit my written testimony for the record.

Senator ERNST. Without objection.

Dr. GRIFFIN. So the recognition of the erosion of U.S. technological superiority, which was once unquestioned in the world, is what led the Congress to establish the position that I now hold, the Under Secretary of Defense for Research and Engineering. Our mission is to ensure that we, if necessary, reestablish and then maintain our technical advantage. I am honored to be here today.

Now, frankly, my involvement with the national security community is of long standing, and so I feel that I come to this position reasonably well-versed in the threats that we face, and I am, therefore, concerned.

We are in constant competition, and the pace of that competition is increasing. In a world where everyone pretty much today has equal access to technology, inno-

vation is important, and it will always be important, but speed becomes the differentiating factor. How quickly we can translate technology into fielded capability is where we can achieve and maintain our technological edge. It is not just about speed of discovery. It is about speed of delivery to the field.

So this is a key tenet of my mission as Under Secretary. My organization will focus on closing the gap on current and emerging threats, on driving the disruptive innovation that provides the technical dominance on the scale and timeline called for in the National Defense Strategy.

In this role, I fully intend to establish the technical direction for the Department of Defense. This is more than just recommending the path forward. My organization must ensure that the future force has what it needs by working with warfighters to develop new concepts of operation through mission analysis and experimentation.

I believe that it is critically important for the DOD to utilize intelligence products, technology forecasting, and our own analysis to inform decisions on where we will invest, what we will prototype, what experiments we will do, and what emerging capabilities and concepts of operation will help us to succeed. To this end, we have established a strategic intelligence analysis cell within the organization that will help us do that.

I will focus on establishing processes and methods to drive effectiveness and affordability by examining our acquisition, testing, and sustainment processes in the system design phase by setting and adhering to open architectures and interface standards while implementing good system engineering and cyber resiliency. Ultimately, I plan to establish and embrace a collaborative culture focused on piloting new acquisition pathways for speed and providing capability to the future force.

The department continues to push research into new technologies such as autonomous and unmanned systems, artificial intelligence, biotechnology, microelectronics, and cyber warfare, both offense and defense. These technology areas are not just important to the Department of Defense. They are, in fact, the focus of global industry, something we must learn to leverage.

The department is not short of innovators. We are short of time, and we lack expertise in adapting commercial market advances to military needs. We need to strike a balance between bringing in new technology and getting current technology out to the field. We need to deal with conquering Senator Ernst's valley of death between innovation and real applications.

One crucial step in this is a comment that the Deputy Secretary made recently. He said, and I am quoting, "Everyone wants innovation, but innovation is messy. If the department is really going to succeed at innovating, we are going to have to get comfortable with people making mistakes."

Increasing the use of prototyping, demonstration, and experimentation will help the department more rapidly mature technology to assess the impact that innovative technologies can have on the future force. Building prototypes and testing them with operators allows the department to speed innovation by driving down technical and integration risk. It also enables us to refine requirements, evaluate new concepts, and get warfighter feedback before we commit to a major program.

Those are the obvious benefits. The less obvious benefits include stimulating industry design teams with new challenges, contributing to new methods of manufacturing, and increasing the likelihood of a successful program by ensuring that we better understand what the requirements are to deliver a real system.

While our adversaries are presenting us with the challenge of a sophisticated, evolving threat, we are prepared to meet this challenge and restore the technical overmatch of the United States Armed Forces through focus, innovation, and rapid delivery to the field.

Thanks again for this opportunity to testify before you on these important issues. I do look forward to your questions.

[The prepared statement of Dr. Griffin follows:]

PREPARED STATEMENT BY DR. MIKE GRIFFIN

Chairwoman Ernst, Ranking Member Heinrich, and distinguished members of the Subcommittee, thank you for the opportunity to discuss technology transition and what the Department of Defense can do to mitigate the infamous "Valley of Death".

The Department of Defense faces a continued challenge—balancing force structure, operational readiness and modernization in an increasingly complex environment. DOD needs to develop new ways to achieve innovation at what Secretary Mattis refers to as "the speed of relevance." This requires a need to move fast to wring out problems through experimentation and prototyping with a willingness to learn from failure rather than design to perfection.

In addition to an increased emphasis on prototyping and experimentation to both identify innovative solutions to our warfighting dilemmas and facilitate their development and transition to a fielded operational capability, we are developing tools that will identify promising, emerging technologies and capabilities to integrate current Department owned models and simulation environments to evaluate their potential, in conjunction with the Services, in Joint simulation environments. Our global technology watch/horizon scanning effort uses data analytics from a wide range of academic, research, and private and public investment data to identify current promising technologies, and forecast emerging technologies that the Department must be aware of to support innovative solutions to regain/maintain our technological edge in a highly competitive global environment. Additionally we are developing a capability to integrate validated Service and threat models into a Joint simulation environment so that we can conduct high fidelity evaluations of these potential capabilities in a mission level scenario so that the Department can gain a better understanding of how these capabilities will work in support of and improve the warfighting capability of existing service programs and force structure.

We are grateful to the members of this Committee for your sustained support of our warfighters, your support of our laboratories and research, development and engineering centers and your continued commitment to ensure that funding is available to provide our current and future warfighters with the technology that enables them to defend America's interests and those of our allies around the world.

STRATEGIC LANDSCAPE

The United States still faces a complex and growing array of security challenges across the globe as described in the National Defense Strategy.

Many factors determine whether or not a technology transitions from the laboratory to the ultimate consumer—the warfighter. These factors include technology maturation, performance, affordability (of the technology and/or the system), manufacturability, available funding, schedule, continued need and/or support from program managers and perhaps most importantly, sustained priority for the technology/system for the Department.

The future force will be smaller, yet must remain capable of conducting the full range of operations on land, including prompt and sustained land combat as part of large, multi-phase joint and multinational operations. The future operational environment is likely to have several characteristics that will have a significant impact on land force operations in the future, including increased momentum of human interaction and events, potential for overmatch, proliferation of weapons of mass destruction, increasing importance of the space and cyberspace domains, and demographics and operations among populations in complex terrains. While the future force will become smaller and leaner, its great strength will lie in its increased agility, flexibility and ability to deploy quickly, while remaining technologically advanced.

While adversaries continue to invest in technology to counter or evade our strengths, insufficient resources and force modernization place at risk our ability to overmatch opponents. To mitigate these risks, the Department must maintain high levels of readiness while also investing in future force modernization. To maintain a decisive advantage over our enemies, the DOD emphasizes the integration of advanced technologies with skilled warfighters.

Despite these great pressures, the Department continues to protect its S&T investments critical to identifying, developing and demonstrating technology options that inform and enable affordable capabilities for the warfighter.

A BALANCED APPROACH TO MODERNIZATION

It is the Department's responsibility to address both current and emerging threats to ensure every warfighter deployed is equipped to achieve decisive overmatch regardless of the situation. As is often stated, we never want to send our Soldiers, sailors, airmen, or Marines into a fair fight. To ensure a balanced modernization strategy is paramount, even under these austere fiscal conditions, to ensure we create long-term investment road maps across all our investment portfolios.

We must focus investments and develop concepts and technology to become more lethal, expeditionary, and agile, with greater capability to conduct decentralized, distributed, and integrated operations. The Department also focuses on decisions and priorities regarding current technology to maintain overmatch, while driving critical capability and technology needed for the future.

Innovation and technology continue to reshape the strategic environment, multiplying and intensifying the effects that even minor actors are able to achieve. Rapidly advancing technologies in many fields may become critical to military effective-

ness; examples include autonomous systems, disruptive energetics, immersive training environments, quantum computing, synthetic biology, alternative power and energy solutions and unprecedented levels of networking capabilities. The Department will continue to develop countermeasures to future threat capabilities and pursue technological opportunities. However, enemies and adversaries will counter U.S. technological advantages through cover, concealment, camouflage, denial, deception, emulation, adaptation or evasion. Finally, understanding how humans apply technology to gain capabilities and train will become as important as the technologies themselves.

The technology playing field is changing. Important technology breakthroughs in many fields are now driven by commercial and international concerns. Our strategy acknowledges the imperative of a global, networked and full-spectrum joint force. It responds to the new fiscal environment and emphasizes new ways of operating and partnering. In a world where all have nearly equal access to open technology, innovation is a critical discriminator in assuring technology superiority.

The Department has identified enduring capability challenges that are necessary to conduct future operations to prevent, shape, and win conflicts, and are used to frame modernization.

The nature of research and engineering (R&E) is such that continuity and stability have great importance. Starting and stopping programs prevents momentum in research and lengthens the timelines for discovery and innovation. While the R&E enterprise gains valuable insight from the intelligence community, this only represents one input to the enterprise and likely describes the most probable future. To have a balanced outlook across all the possible futures requires that the portfolio also address the "possible" and "unthinkable."

SOLVING CURRENT PROBLEMS

As noted before, it is the expertise resident within our R&E enterprise that enables our ability to respond to warfighter urgent needs in a timely and effective manner. The familiarity of our workforce to the operational environment helps them to quickly assess the ability for commercial solutions to meet the need (either with or without modifications) and/or identify developing capability that could address the immediate needs of the warfighter.

A strong organic research and engineering as well as technical workforce is critical to the Department's effort to retain the U.S.'s technical advantage over our adversaries. A major challenge facing the Department, as well as industry in general, is identification and recruitment of technical professionals with specific skills, experience, and knowledge in advanced technologies. In order to address technical workforce challenges and continue to close our capability gaps, we are leading many initiatives to enable the Department to hire people with critically needed technical skills as well as equip our current workforce with these skills.

Furthermore, DOD must build a human capital development program incorporating both traditional and non-traditional STEM careers paths that put the right technical talent and innovative talent in touch with the warfighter. This requires building tailored programs that create the necessary skills and social networks, develop the right risk taking culture and marries it with the opportunities to experiment. This is as simple as linking recipients of DOD STEM scholarship funding starting with undergraduate education to research laboratories and academic institutions through postdoctoral fellowships. To that end DOD increased STEM education funding beginning in fiscal year 2019 to support DOD initiatives in Artificial Intelligence, Microelectronics, Hypersonics, and Biotechnology.

DRIVING DOWN TECHNICAL RISK

In this time of decreased modernization funds, it is incumbent upon the R&E enterprise to drive down the technical risks associated with developing new capabilities.

Congress has supported the Department over the last few years. One such way is by passing legislation in the fiscal year 2017 NDAA, section 901 establishing the USD(R&E) with a focus on maintaining technology superiority. The USD(R&E) focus will drive down technical and integration risk through the extensive use of prototyping and experimentation, gain warfighter feedback to better inform requirements; to ensure that concepts going forward into acquisition not only provide the needed capability, but are timely and affordable.

Another was fiscal year 2017 NDAA language to ensure that all major defense acquisition programs have a modular open design, to the maximum extent practicable, and a technology refresh strategy built in, prior to them being permitted to move forward into development. In response to the Acquisition Agility Act, the DOD

employed a cross-functional team that developed policy changes, started establishing a body of practice, and began training acquisition program staff to assist the workforce in implementing more rapid/agile acquisition of capability for the warfighter. Program-specific examples include:

- *Blue Guardian (Air Force Research Laboratory (AFRL)-led program).* Due to the adoption of Modular Open Systems Approach (MOSA) in the USAF Open Mission Systems (OMS) architecture, the Air Force was able to support the rapid acquisition of advanced C4ISR capabilities faster and cheaper than existing methods.
- *Army Common Operating Environment (COE).* The Army has adopted MOSA for its mission command systems, COE, to provide a common foundation of shared components and standards across key systems, allowing the Army to design, develop and deliver capabilities more effectively than the previous method (of using three different systems having different designs and standards).
- *Navy Submarine Warfare Federated Tactical Systems (SWFTS).* Due to the adoption of modularity and open business practices, Navy common submarine combat system programs, collectively known as SWFTS, were able to speed the delivery of advanced technologies and capabilities while driving down integration risks and life-cycle costs across multiple submarine classes.

By moving toward modular, open designs for architectures in this and other areas, we are creating systems that are easily upgradeable as new threats emerge. We are also making it easier for small, innovative businesses to contribute their technologies.

IDENTIFYING AND MITIGATING SYSTEM VULNERABILITIES

New theaters present new challenges—we anticipate facing future operations against technically savvy opponents who will challenge our military superiority. This effort looks at vulnerabilities in both individual technologies and systems, providing timely feedback to technology and materiel developers in order to increase awareness of potential risks (in context of future scenarios and threats) and to identify opportunities for technology and/or employment improvements. These efforts have the potential for significant cost savings, as vulnerabilities are mitigated before system designs are finalized and/or systems are fielded. A key aspect of this initiative is red teaming, challenging the systems with an emulated enemy—one who can use innovative and adaptive methods to disrupt the planned capability. This has proven to be an effective method to tease out inadvertent seams that result from the introduction of new technologies and systems into operational use.

One way we are accomplishing this is through Red Teaming activities, in which we provide technologists and systems developers with realistic and challenging scenarios where they can employ and assess their solutions prior to acquisition. These activities are envisioned to take emerging systems and prototypes out of the lab and into "messy" environments, incorporating varied operational and increasingly complex scenarios against capable adversaries, as well as experienced warfighters and security forces that provide real-time user feedback on design and performance. In these settings, technology solutions are examined from multiple perspectives—including systems integration, logistics, training and adaptability risks—in order to expose potential employment vulnerabilities and identify needed improvements early on.

UNDERSTANDING THE GLOBAL TECHNOLOGY ENVIRONMENT

Understanding the current and projected threat environment is essential as we develop future capabilities. To foster greater innovation within the R&E enterprise, we are identifying concepts and conducting technology-based assessments about what S&T will look like in the deep future (the 2030–2040 timeframe) and how this will affect both the Department and our adversaries. We are taking a multipronged approach that includes brainstorming from government, industry and academia, and red teaming of potential technology concepts. At the heart of this initiative lies a commitment to solid analysis and a focus on bringing fresh ideas from a wide community, including innovative thinkers who haven't traditionally been a part of the planning process.

Our red teaming/vulnerability analysis activities are fostering closer ties between S&T and the intelligence community, a partnership that is increasingly important as we look beyond the recent wartime period into a more complex and unknown future.

CONCLUSION

As the Department's R&E enterprise continues to identify and harvest technologies suitable for transition to our force, we aim to remain ever vigilant of potential and emerging threats. We are implementing a strategic approach to modernization that includes an awareness of existing and potential gaps; an understanding of emerging threats; knowledge of state-of-the-art commercial, academic, and government research; as well as a clear understanding of competing needs for limited resources. The Department will sharpen its research efforts to focus upon those core capabilities it needs to sustain while identifying promising or disruptive technologies able to change the existing paradigms of understanding. Ultimately, the focus remains upon our warfighters; we consistently seeks new avenues to increase the warfighter's capability and ensure their technological superiority today, tomorrow, and decades from now. Our mission is not complete until the right technologies provide superior, yet affordable, overmatch capability for our Soldiers, sailors, airmen, and Marines.

All of the efforts described above would of course be impossible without the continued support of our partners in Congress. I would again like to thank the subcommittee for your long-standing support of the incredibly important work of the Department's R&E enterprise. I am extremely proud to represent the men and women who have dedicated their lives to provide our warfighters with the capabilities to operate in any environment and situation. Thank you. I would be pleased to answer any questions you have.

Senator ERNST. Wonderful. Thank you very much, Mr. Secretary.

We will go ahead and get started with the questions, and, hopefully, we will get a couple rounds in.

We were just talking a minute ago about the National Defense Strategy. It was recently released by Secretary Mattis, and it focused on competition with near-peer adversaries.

Dr. Griffin, how do you envision your position helping DOD to address the technical shortfalls in specific fields like A2/AD [Anti-Access/Area Denial] and other high-end capabilities being developed by our near-peer challengers, like China and Russia? What can we do there, in your position?

Dr. GRIFFIN. Our adversaries have taken advantage of what I have referred to as a holiday for the United States. It has not been exactly that, but with the fall of the Berlin Wall in 1989—I was in the Pentagon when the wall came down and when the Soviet Union broke up. We had won the Cold War, and we had no major adversary in the world. We declared a peace dividend, and we felt we had won.

The winners never learn anything, and the losers always do. So over the course of the 25 years since that has happened, China has understood fully how to be a superpower. We gave them the playbook, and they are executing. Russia, after a period of very difficult times for them, is now resurgent in the world of global and great power competition. These are the things that our National Defense Strategy calls out.

We have been occupied for 15 years in the Middle East dealing with the urgent problem of terrorism and nonstate warfare, and other very, very difficult problems, but problems which are not existential for the United States. They are difficult, important and concerning, but they are not existential.

Our global power adversaries are existential threats, and this is what the National Defense Strategy is saying. I am tremendously pleased with that strategy. I regret to say I did not offer a contribution to it, but I am delighted with what they have put forth, and I think that should be our bible.

Senator ERNST. Then in your position, how do we use the expertise that you have to catch up to those near-peer adversaries?

Dr. GRIFFIN. Well, in certain areas, like you mentioned, anti-access/area [A2/AD] denial, China has fielded or can field, is close to fielding, hypersonic delivery systems for conventional prompt strike that can reach out thousands of kilometers from the Chinese shore and hold our carrier battle groups or our forward-deployed forces on land that we have bases, can hold those power groups at-risk. We, today, do not have systems that can hold them at-risk in a corresponding manner, and we do not have defenses against those systems.

Should they choose to employ them, we would be, today, at a disadvantage. It is among my very highest priorities to erase that disadvantage, creating our own systems to hold them at-risk and to provide defense.

We will never win a man-to-man conflict with the Chinese, should that come about. We can only win by employing technical overmatch.

So, for example, in the areas of missile defense or air defense, or even with our ground forces, in order to deal with things like swarming drone attacks, we have

to finish the development of directed energy weapons, which started and some years ago decided we did not really need. Well, we need to decide that we really do need them and fund them to completion.

We need to have 100-kilowatt class weapons on Army theater vehicles. We need to have 300-kilowatt class weapons on Air Force tankers. We need to have megawatt class directed energy weapons in space for space defense. These are things that we can do over the next decade if we can maintain our focus.

Senator ERNST. I appreciate that. We do need to maintain our focus.

With that, we will go to Senator Heinrich.

Senator HEINRICH. Secretary, yesterday, you testified before the House Armed Services Committee, and I saw a little bit of that. I believe you said that the powers afforded to you in this new position are more like "broad and sweeping powers to offer advice."

Can you tell me a little bit more about exactly what you meant by that? And what do you think should be your authority and relationship with service research and engineering programs and activities?

Dr. GRIFFIN. Well, that is a leading question, sir, but I will take a swing at it.

Senator HEINRICH. It was meant to be.

[Laughter.]

Dr. GRIFFIN. Yes, sir. The authorities that the USD (R&E) [Under Secretary of Defense for Research and Engineering] has do not include the ability to direct funding. They do not include the ability to direct programs or program direction. So, therefore, the office is persuasive or advisory in nature, and I think that is what I said yesterday. If not, it is what I should have said.

So, let me be clear. I think that in the NDAA 2017 and 2018 legislation that was passed, I personally believe it was a very good idea to delegate programs back to the services to run on a day-to-day basis, except for those few programs that the Secretary has determined should be held at the OSD [Office of the Secretary of Defense] level. I am an unabashed supporter of that plan. OSD, generally speaking, is not the place you want to run programs.

However, the industry analogy, which I have used, might be that OSD is what you might call in industry the vice president for programs, for all programs. You are not running the program, but if a given program or a given program manager gets off track, in industry, there is no fuzz on this. There is a vice president somewhere who will say, "What you are doing is not okay. I am not replacing you. You still have the program, but you cannot do what you are doing, and you are going to do this other thing instead, and the reason is because I am the boss and I said so."

In industry, one's very existence depends upon being able to do that. The wrong decisions can put you out of business. I have run two companies, and we did not run them on the committee system.

That situation, I think, gives you a flavor of the kind of authority that we need to have. We do not in OSD, in my opinion, need to be running programs. But we need to be able to control the funding and the overall direction of those programs in a way that is collaborative, but in the end, when a decision is made, the decision is made.

Senator HEINRICH. I think we agree that you should not be meddling in the day-to-day management, but we want to make sure that the strategic direction that you set is how these programs execute.

I am also concerned that the services have not always prioritized the modernization of the testing infrastructure, which is incredibly important if we are going to maintain our position in the world.

If you just look at one example that I am familiar with, White Sands Missile Range went 18 years straight without receiving a single milcon [military construction] project. It is not unusual—White Sands is not alone in seeing that sort of dynamic among our test ranges.

So I am curious, how can you help to ensure that Test Resource Management Center is not only planning for testing but planning to make sure that we are maintaining our test ranges, that we are investing milcon in them, and that we are not ignoring the center's imprtance and standing?

Dr. GRIFFIN. Senator Heinrich, you have hit one of my hot buttons. I was just speaking about conventional prompt strike and hypersonics and the need to develop both offensive and defensive capabilities.

I would tell you right now that DARPA [Defense Advanced Research Projects Agency], which reports to me and has done some of the most significant hypersonics work in the country, has basically one wind tunnel that they can use for hypersonic research today. It is at NASA Langley Research Center in Virginia. This is an unacceptable situation.

Regarding your example of the test range at White Sands that has not received milcon funding in 18 years, I could tell that same story for about 20 other test ranges and test facilities, and 20 is an undercount.

The Nation must invest in renovating our test facilities, our research facilities, and bring them up-to-date. We must do that.

Now, it is not glamorous. But when I come to you with a budget that asks for money to renovate our test facilities, I really want you to take me seriously. It is not nice to have bad conditions at test facilities. We really need to bring these things up-to-date.

Senator HEINRICH. These are fundamentals.

My time is up, but I look forward to continuing——

Dr. GRIFFIN. I am sorry. I was possibly too long-winded, but you asked me things that I am passionate about.

Senator HEINRICH. We are going to have a couple rounds, I hope.

Senator ERNST. Yes, absolutely. Thank you.

Senator Perdue?

Senator PERDUE. Thank you, Dr. Griffin. I appreciate you being willing to take on this job.

Dr. Eric Schmidt yesterday testified that, if there were one variable to solve for, it would be speed. You mentioned speed this morning several times. I just got back from a trip to China, and I saw firsthand how they are leapfrogging entire industries.

The Chinese Government put $152 billion into creating a chip industry. They bypassed their entire telecom industry. There are no hardwired cables, et cetera. It is all moving to 5G.

We saw corporate businesses and their research aligned with defense research all under one umbrella inside the Chinese structure.

The way they are set up is entirely different from ours. They are able to build things and move more quickly than we are in a democratic society.

Secretary Mattis said constrained budgets and acquisition regulations have limited our ability to keep pace with rapid changes that sustain our competitive advantage.

Combine that with the Defense Innovation Unit-Experimental [DIUx] releasing its report recently, it really concerns me because of having seen the Chinese ability to move very rapidly, and our ability to build a 2-foot tall set of requirements to buy a new pistol for the Army.

So the question I have for you is, within our DOD procurement system, our DOD requirements system, and the ability to innovate within a system that has been choked up by all the things that you are talking about—China is buying technology from us; they are stealing technology from us; and they are innovating on their own today at a level that we have not seen.

When you look at the two domains, in space and in cyber, particularly, I am worried about whatever advantage we might have dreamed we had may have dissipated already.

So my question is, in that environment, how do we develop, from your point of view in R&D—I hear infrastructure first. I get that. What are the ways, in integrating with business—you read the Defense Innovation Board report. What ways can we accelerate the innovation that we obviously need to be able to defend our country in this new technical world that we live in?

Dr. GRIFFIN. That is a great question. Of course, I testified yesterday with Dr. Schmidt, and we did not pre-coordinate our views, but he and I are about as closely aligned as I think two people from very different backgrounds could be about what is needed.

So one of the things that we have both said is that, and I will use my words, we cannot punish people who take risks and break something. We should reward them.

I will offer the view, which may not be popular, that it is not actually, generally speaking, our laws and regulations that restrain us from moving more quickly. It is the cultural view of our—and it is not even just within the Department of Defense. I saw many of these same things at NASA, and I worked in the intelligence community.

It is the view that we have taken in recent decades that any mistake is made in the course of a new development is a punishable offense. So, therefore, any rational program manager, whether wearing colonel's eagles or SES civilian, will do everything possible not to allow any step of the development to turn out wrong because they will be punished.

Senator PERDUE. Do you think the new generation of military leadership at the top recognize that?

Dr. GRIFFIN. I think they do. The people that I work with every day recognize the cultural barrier that avoidance of risk has created for us. But I need your help as legislators to make sure that our people understand that failure is not okay, but failure is failure to reach the end goal.

If I fail to give you a 100-kilowatt laser weapon for an MRAP within a few years, you should ding me for that. You should not ding me if we go out into the desert and try a couple laser concepts, and one of them does not work, and we have to back up and try another. That is not failure. Failure is if I do not get to the goal.

All too often, we punish program managers because they take something out to the desert and they flight test it and it breaks.

Until I was 40, I was closely involved with hardware development. I will tell you, it is really hard to get it right the first time.

You have to have that freedom to take on new challenges, take new risks, let things break, figure out why, and move on to the next step without punishing the young folks who want to learn all those lessons.

There is no more critical step than that to me, sir. That is how we can establish a new culture of speed and innovation.

Senator PERDUE. Is that inside DOD? It is also in the procurement area as well, right?

Dr. GRIFFIN. It is in the procurement area. It is inside DOD. It is really all across government. It really is.

You have given us a lot of new legislative permissions. And you know what? As Eric Schmidt said yesterday, you should ask us to keep count of the number of times we are using other transaction authorities instead of the regular FAR [Federal Acquisition Regulation]. You gave us permission to use them. You should require us to do so. You should not allow us to fall back on what we are culturally familiar with.

Another point that I will make, and I realize I am over time, another point that I will make is that the whole purpose of carving out or separating R&E [Research and Engineering] and A&S [Acquisition and Sustainment] from the former acquisition, technology, and logistics was to provide an organization which could do advanced development before it got into the major production cycle.

So let us make our mistakes. Let us learn our developmental lessons when it does not cost much. Let's not learn it when the carrier is already in production. I am not picking on carriers. You pick your system. Let's not learn it when the system is in production. Let's learn it while people are still experimenting.

That is a critical step. I am sorry I have overstayed.

Senator ERNST. That is okay. Good discussion. I appreciate it.

Senator PERDUE. Thank you, Madam Chair.

Senator ERNST. Senator Peters?

Senator PETERS. Thank you, Madam Chair.

Thank you, Dr. Griffin, for being here. Your discussion about failure as part of the process, as you are talking, I am just reminded of Thomas Edison. I cannot remember the exact quote, but I think he said that he spent most of his career with failed experiments. But the ones that worked were pretty big and changed the world.

Dr. GRIFFIN. Well, the knowledge that a particular approach does not work is every bit as valuable a piece of knowledge as the knowledge that something does work.

Senator PETERS. Absolutely, yes.

Dr. GRIFFIN. I am not suggesting that we embrace stupid decisions. I am not going to that place at all.

What I always tell my people is, every mistake you make, I want it to be a new mistake. Make a new mistake. Just do not repeat the old one, and we are good.

Senator PETERS. Right. As long as you are learning from it.

I wanted to pick up on your comments related to speed as well. I think the other thing that I think was significant was where you said that everybody has access to this technology, which has changed so dramatically. The area that I have spent a lot of time on, being a Senator from Michigan, is self-driving vehicles and autonomy, which is moving I think a whole lot quicker than people realize as well. The race with the Chinese, Senator Perdue comments, I know they are at full speed on this as well.

What people have told me about the power of the self-driving cars is that, in order for it to work, you need to have further advances in artificial intelligence and machine learning that is able to process the massive amount of data that is coming in. In fact, it was described to me, in some ways, self-driving cars is the moonshot for AI [artificial intelligence]. When AI can pilot that car through a street here in Washington or New York City safely with all of those inputs, that means AI is

ready for prime time in every single industry and will likely change everything about our world. That also means the future of warfare as well. I know the Chinese are working on that at a feverish pace as well.

So I wanted to ask you about reports I have seen about the DOD and the intelligence community working to create a Joint Artificial Intelligence Center that will hopefully move us along quicker with some of these kinds of developments.

I am currently working on some language for the NDAA provision that will create some flexibility so that we can move forward with AI and incorporate all that we are seeing on the commercial side into applications that will change the face of warfare in ways that I do not know that we can fully appreciate at this time.

So my two questions are, first, can you speak to the reports of this joint AI center, and how we can help here on the committee to make that kind of effort a reality where we are coordinating our activities and taking advantage of what is available commercially?

Dr. GRIFFIN. In answer, sir, to that question, yes, the Secretary in his testimony, I believe just last week, committed to the development of a joint AI center, meaning across the services.

Really, there will be elements of it across government. I think the DOD will take the lead. The organization of all that has not been finally decided, as you might appreciate. But the Secretary and the Deputy, I believe, had made the decision that there will be such a center. I am working right now with folks on my staff to answer questions, like who should lead it, where should it be, what projects should it do, and, most importantly, how does such a center fit into the overall AI strategy for the department and the Nation, because there are 592 projects, I was told, in the department, which have AI as some piece of them. They do not all belong in the new AI center that we will create, but some of them do.

We have things all the way from foundational research to practical applications to put in theater tomorrow. So we have to parse all that.

We owe the Congress a report, I think about 2 months from now, on what our AI strategy will be. The JAIC, the Joint Artificial Intelligence Center, will be a part of that overall strategy.

I better asked than answered your question.

Senator PETERS. No, it is good. Is there anything that we should be doing here in Congress to move this along?

Dr. GRIFFIN. No, I think we can do this with the authorities that we have. If we stumble across a regulatory issue where we need your help, I will be back on your doorstep in a heartbeat, because I agree, this is a critical area of research. If there is going to be a leader, we need to be that leader. We are not going to let this slip through the cracks.

Senator PETERS. Like most technologies, being first is a significant competitive advantage. But I understand, with artificial intelligence, it is beyond a significant competitive advantage. It may be everything, in a lot of ways.

Dr. GRIFFIN. Yes, I do not want to be in danger of getting overly occupied with the new shiny object. I think AI is critical.

I think, frankly, we are going to have self-driving vehicles in theater for the Army before we will have self-driving cars on the streets. But the core technologies will be the same. We in the DOD absolutely must leverage, I do not want to get into corporate names, but what the various companies are doing in developing self-driving cars.

I will give you an example that I have heard the Secretary use, and I will put numbers on it. In theater, 52 percent of our casualties have been from soldiers basically delivering the mail, not literally the mail, but food, fuel, logistics, things like that. You are in a very vulnerable position when you are doing that kind of activity. If that can be done by an automated, unmanned vehicle with a relatively simple AI driving algorithm where I do not have to worry about pedestrians and road signs and all that, why wouldn't I do that? Well, I will.

We do not have that capability yet, but that is the kind of thing that we could bring to bear fairly easily. And if you will forgive the expression, we do not have to solve world hunger with AI to be able to deliver a system that can deliver fuel.

So that might be an early win for us. That is just one example.

Senator PETERS. Thank you. I appreciate it.

Dr. GRIFFIN. Thank you, sir. I thought that was a great question. Thank you, sir.

Senator ERNST. That was very good.

And thank you, Senator Peters.

While we are talking about commercial technology as well, this is a nice segue. During World War II, as well, we saw that the United States needed to rapidly leverage the commercial industry to meet its wartime needs, and we were able to do

that in World War II. The phrase "battle of production" encapsulated our ability to outproduce many of our adversaries. That was critical in securing our Allied victory.

In future conflicts, the ability to out-innovate those adversaries—we have named Russia; we talked about China—they will be just as important. And we still do have a world-class tech sector. We really do.

So what we would like to see is that we are able to take full advantage of that world-class tech sector. But unfortunately, there seem to be some gaps there where we are not able to tap into some of those technologies.

So the department is starting to make an effort to engage the commercial sector and get into that innovation coming from places like Silicon Valley. We will not name any names out there. But they are trying to do that through organizations like the Defense Innovation Unit-Experimental, DIUx—you mentioned them earlier—and the department's Silicon Valley outreach office.

So as we are trying to do that, what are the biggest barriers that you see with being able to reach that goal of utilizing those technologies that have been commercially developed?

Dr. GRIFFIN. One of the barriers that we have is that, whether in AI or any other kind of information technology type of thing, or whether in fundamental material science or microelectronics, most of the innovators are innovators in small companies. Most of those companies fail.

I used to run In-Q–Tel. I would split time between

Washington, D.C., and Silicon Valley. I had it an office on Sand Hill Road. In-Q–Tel, of course, is the CIA's venture capital company, if you want to put it that way.

Nine out of 10 of these entrepreneurial companies fail, and that is a real statistic. They should fail. They were experiments that tried and did not work. But the ones that succeed become things like Google Earth or other huge successes that become household names.

Well, the benefit for the department and for the U.S. Government more broadly is to be able to tie in on the front end of some of these things, because several of us have talked about how technology today is instantly available everywhere. Well, we do not want to be behind our adversaries in adopting the technology that we, this Nation, create.

So the earlier we can get into the tech cycle in whatever field and work with those people and bring them into department utility, the quicker we will transition to the field. Well, how do we do that with young companies?

You asked what the barriers were. The barriers are they are small, young companies. They cannot possibly afford the overhead of dealing with the DCAA [Defense Contract Audit Agency] accounting system. They cannot possibly afford the barriers of dealing with the DCMA [Defense Contract Management Agency] for contracts. I mean, it takes a full-time staff of a good-sized company to deal with that.

So we have to have ways of interfacing with them that recognize where they are in the corporate lifecycle. They are not a large prime. If we want to take advantage of what we can bring, we have to work with them on their terms. That is what, for example, DIUx strives to do, but DIUx is a few tens of millions of dollars a year.

This is really a cultural issue. We need, across the department, to learn how to become user-friendly in our contracting and financing, so that any piece of our department can work effectively with a new high-tech provider.

Now U.S. Special Operations Command is an artist at this. SOCOM absolutely knows how to do this. DIUx is an excellent idea. I am fully supportive of it. But they are not the only place in the U.S. Government or even in the department that knows how to do this.

These are the kinds of lessons that we need to promulgate.

Senator ERNST. Very good. Thank you. My time is expiring, so, Senator Heinrich?

Senator HEINRICH. Secretary, I really appreciate your awareness that so many of these challenges are baked into culture as much as anything else.

I want to give you an opportunity to talk a little bit about directed energy. I know you are passionate about it, as am I. I have a bunch of questions, but at the front end, I just want to provide you an open opportunity to tell me what you are excited about right now, where you think things are going, and how we are going to finally make that transition from R&D into procurement.

Dr. GRIFFIN. Thank you, Senator. I do appreciate the opportunity. So let me answer the last part first.

The way to get from experiments into procurement of real live weapons systems is to say that is what we are going to do, appoint people to run those programs, and hold them accountable for delivery, and ask them every day, "What is in your way that I can clear out?"

The technology is there or almost there. I used an example earlier: Let me have 300-kilowatts on an Air Force tanker so that the tanker can defend itself, because that is a critical function in our maintenance of air superiority.

And there are others. I am neither picking on the Air Force nor otherwise. It is just an example.

I do not have a 300-kilowatt laser today. I have been in the directed energy community, at least on its periphery, for 3 decades. The people that I talk to who are domain experts today, and from my own background, I can tell you that if we can persist for 5 or 6 years, we can have that laser. If we can persist for 10 years and maintain our focus, we can have the megawatt class space laser that I want. If I can persist for just a few years, I can have the laser that goes on an Army combat vehicle.

You will notice that the key word there is "persist." We have to set our goals and move toward them and weed out the funding for interesting ideas but which are not on the mainline of development and have people stick.

So that is what it takes. That is the cultural behavior that it takes to get things to the field.

I have already alluded to what level of performance we can have. Today, we have two very promising approaches, diode-pumped alkali laser that are being developed at Lawrence Livermore lab by the DOE [Department of Energy]. I keep talking about across government. It is not just the department. The DOE is our ally in this. And we have fiber combined lasers being developed both by industry and by government laboratories. In particular, Lincoln labs has demonstrated 35 kilowatts of controlled power.

You are getting very close there to something that will allow us to defend our forces.

So we have good technology paths. We have good laboratories. We have a good industrial base. And you have somebody with me who wants to bring that to our troops.

When I interviewed for this job with the Secretary, there was a comment he made that, until I either die or get Alzheimer's, I will not forget. He said to me, when I was in theater, I never had to have a fair fight. And he said, you are in charge of making sure that the future force never has to have a fair fight.

To me, directed energy weapons are one of those ways that we do not have to have our guys, our partners, our allies have a fair fight.

Senator HEINRICH. That is right. This is the third offset, in terms of technology.

As you identify those obstacles in the way, make sure that we know, so that we can help remove those obstacles.

Dr. GRIFFIN. You can count on it, Senator. Thank you.

Senator HEINRICH. In a related question, I want to ask you about the role of requirement setting.

To put it simply, I think that the current requirements process is not designed for new ideas or new weapons systems. It is almost designed to impede the movement from well-established systems to the next step. So talk to me about that a little bit.

I guess I am running out of time.

Senator ERNST. Go ahead.

Senator HEINRICH. How do you think the current process actually works? To me, it seems like it slows down our progress into these new systems. How do we fix that?

Dr. GRIFFIN. Well, from an engineer's point of view, we have requirements and capabilities backwards.

If you are in the DOD acquisition cycle, the DOD Directive 5000, et cetera, you have to have requirements before you can put out an RFP [request for proposal], before you can, before you can, before you can, move down the road. But the reality is that engineers really do not know what the requirements ought to be until they have built and tested something.

Frankly, whether it is a piece of software or a new combat vehicle or a new pistol or whatever, you have to build it and try it out and fool around with it a little. I am sorry to be so colloquial, but that is how engineers really work in the real world.

You [Senator Heinrich] are an engineer by training. I know you know what I mean.

When I know about what the capabilities are that the current generation of technology will allow me to have, and when I have tried it out with a real operator, then I can sit down for you and write some requirements. But if I have to write the requirements first—despite what some think, I am not actually stupid. I am never, ever going to write a requirement for something that I do not already know

I can do. Why would I do that? I am going to write a requirement for something I cannot get? That is just insane.

So the requirements before capabilities process, what that does to you is it constrains your ability to innovate, to get anything that you do not already have, because you must be so conservative in your process. That is at the root of our difficulties.

Senator ERNST. Mr. Secretary, we will do one more round. We have a couple more questions.

We have talked about some of our adversaries, near-peer adversaries, and the technology that they have developed over the course of the last several decades. What can we as the United States be doing to make sure that we are tracking the advancements in technology that they have, as well as developing our own?

What we really need to see is that the United States is, again, staying ahead of our near-peer adversaries. You just stated that we do not want to see our warfighters in a fair fight. So what can we do to make sure that we are outpacing our adversaries?

Dr. GRIFFIN. Well, certainly, our intelligence-gathering apparatus is critical to that. I met yesterday with some of my Title 50 colleagues. We need to take a whole-of-government approach on this.

Within the USD(R&E), we have a group who are focused on protecting our own technology, making sure that foreign acquisitions are appropriately vetted against strategic considerations. We have to protect what we have while not impeding our ability to have our companies compete in the real world, because we cannot wall ourselves off and stay inside. We have to be prepared to compete. At the same time, we have to protect ourselves, and we have to do that in balance.

But if you ask what we need to do to regain and maintain a technological advantage on our adversaries, frankly, we have to work harder; we have to run faster; we have to have more focus on what we want to do.

No adversary of ours at present has directed energy systems of the type of which I was just speaking. We should be the first. We should be putting them in a position to catch up with us.

I have mentioned you can find in public literature many references to the Chinese hypersonics capability development. Frankly, we were the leaders in that 10 and 15 years ago, and we just let it drop. We need to get started again.

We need to shorten our test cycle timelines. I referred yesterday to an experiment called Flight Experiment-1 [FE–1] that the Navy did, a long-range conventional prompt strike experiment. It was, frankly, an experiment. It is not a weapons system yet. They did a brilliant job with it. I mean, I will not quote numbers, but I will just say that the impact accuracy was quite impressive.

So in chatting with my colleagues at the senior levels of the Navy, I said, well, when can I have FE–2? When can I have FE–3? Why not next August? Why not this August?

I mean, we need to finish the development of these systems, and it cannot be done at a leisurely pace, because our adversaries are not working at a leisurely pace. As much as anything else, it is the sense of urgency, Senator, that we really must get to this.

Senator ERNST. Very good. I will just make a brief comment. I think we have talked a little bit about some of the issues, and what we have described as the Valley of death, actually taking that technology and getting it fielded for our warfighters. It seems like the overarching theme seems to be the persistence and funding.

Would you state that that is accurate?

Dr. GRIFFIN. Senator, absolutely. Persistence in reaching the goals, knowable funding to reach the goals.

I can deal with budget cuts. What I cannot deal with is surprises. Or I can, but the surprises become very expensive for you and insert delays for me.

The other thing that I guess I would offer is we have to regain a cultural awareness that we have, as the National Defense Strategy states, global superpower competition again.

I was once labeled by a political adversary as an unreconstructed cold warrior. I took that as a compliment, actually, though it was not meant that way. Much of my early career was in the Cold War. We understood for decades that we had an existential threat from a peer competitor, and Democrats, Republicans, did not matter, did not matter which presidential administration, we had for decades a united policy across government that we were going to contain the Soviet Union and we were going to win. And if we can restore that kind of thinking to a renewed global power competition, then we will actually never have to fight, because our adversaries will not want to take us on.

So that is the kind of culture, those are the kinds of comments that I hear coming out of my leadership, which I would like to promulgate as well.

Senator ERNST. Thank you. I appreciate it.

Senator Heinrich?

Senator HEINRICH. Thank you for bringing a sense of urgency to all of this, because I very much agree that has oftentimes been the missing piece to all of this.

I wanted to follow on to the question that Senator Perdue asked you. You did a really good job of articulating why testing is so important, and why you want to do testing very early in the process and not after you have a product that is supposed to work perfectly for folks in the field.

Can you talk a little bit, too, just about how early and effective developmental testing also speeds up acquisition by discovering challenges early in the lifecycle and not after the fact?

Dr. GRIFFIN. Sir, I think you have pretty much done it for me. The truth of the matter is—Senator Ernst was just asking about persistence and funding, and how to get through the valley of death. My quick answer to that is, take your prototypes up to the level of being operational prototypes, not something I am going to produce but something a real operator can work with and help wring out the bugs so that I know what I want to produce.

The more quickly that I can do that, and I will say outside the acquisition cycle—although, of course, it still is Federal acquisition of stuff with taxpayer money, but it is not in the production cycle. The quicker I can do that and figure out what I really want, then the speedier the whole acquisition process will be.

The most expensive and time-consuming place to discover a mistake is after I have delivered a weapons system to the field.

So when someone has spent the most enjoyable part of one's life as an actual engineer, you become humbled by the fact that you almost never do anything right the first time. It is a bit embarrassing because there are very few stupid engineers around, and all of us have advanced education, and you would like to believe that you can get something right the first time. You just cannot.

Senator HEINRICH. Experience does not support that.

Dr. GRIFFIN. Yes. So wring the mistakes out as early as possible. Work with us. Talk with us. Call us up to the Hill frequently and say, "Hey, how are you doing on that Flight Experiment-2 that you just talked about with the Navy? How is that coming along?"

Senator HEINRICH. You mentioned a laser that DOE is developing. Before we let you go, is it easy enough to work across government? If DOE or the NNSA, the national security labs, are developing something that has direct application in DOD, do the authorities and the current ways of interfacing, do they support being able to work together? Or are there things that we need to change in the NDAA to make it easier to do that kind of work?

Dr. GRIFFIN. Senator, if I come across something that should go in the NDAA, that would enhance our ability to work across government, I and the department will come to you with a legislative proposal. I have spent decades in various agencies working with other agencies, to include at various times in various places NASA, National Reconnaissance Office, DOE, CIA [Central Intelligence Agency], DOD, of course, working in and with these various components of the government. When you get below the very political level and you start dealing with people whose focus is on the mission, I have never had any trouble at all.

Senator HEINRICH. That is good to hear.

Dr. GRIFFIN. It works well. I am not saying there are not stumbling blocks. It is always difficult for people to work together. But my experiences have been good ones, I will just say that, over the years.

Senator ERNST. Thank you so much, Mr. Secretary. It has been a pleasure to have you in front of the committee. We appreciate you taking on these challenges for our men and women, whether they are on the frontlines or working in various places around the globe.

We look forward to utilizing your expertise in the upcoming years, and I am anxious to see some of the great developments that will come through your work.

Dr. GRIFFIN. Well, you have given us a wonderful budget, and you have given us good regulatory authorities, and we have a great team. It is on us, and we hope to deliver.

Senator ERNST. Outstanding. Thank you. This concludes the Emerging Threats and Capabilities Subcommittee.

[Whereupon, at 3:30 p.m., the subcommittee adjourned.]

[Questions for the record with answers supplied follow:]

QUESTIONS SUBMITTED BY SENATOR DAVID PERDUE

LEVERAGING THE CYBERSECURITY EXPERTISE IN THE ACADEMIC COMMUNITY

1. Senator PERDUE. Dr. Griffin, cybersecurity is a rapidly evolving field, as the number of threats from nation states, terrorist organizations, and individual hackers increase daily. These threats include proliferation of Internet of Things technologies, converged systems, and the vulnerabilities of machine learning applications. There is cutting-edge work in the academic community to understand state of the art cybersecurity capabilities and deliver new products to the Department. For example, in my state, Georgia Tech's Institute for Information Security and Privacy brings together computer scientists, electrical engineers, policy and international relations experts, and business professionals to gain a holistic understanding of cybersecurity challenges and develop technologies and policies to appropriately address these issues. How is the DOD, as well as each of the Services, leveraging the cybersecurity expertise in the academic community to prepare for both near- and long-term threats?

Dr. GRIFFIN Cybersecurity is one of my top 10 priorities for research and engineering. There are a variety of mechanisms we use to engage academia on this topic. A number of our University Affiliated Research Centers (UARCs) are engaged in cybersecurity activities with DOD and the Military Departments. Through the Systems Engineering Research Center (SERC) UARC, Georgia Tech Research Institute (GTRI) has collaborated with the University of Virginia to prototype system sensing technologies that monitor system operations for cyber threats. GTRI is also supporting an effort to shape future university engineering curriculum strategies to address engineering of cyber resilient weapon systems. The Department also engages universities using Broad Area Announcements. For example, Defense Advanced Research Projects Agency (DARPA), funded a four year project as part of the agency's Harnessing Autonomy for Countering Cyber-adversary Systems (HACCS) program. Finally, the Army Research Office, the Office of Naval Research and the Air Force Office of Scientific Research execute $46 million in basic research related to cybersecurity through individual investigator and Multidisciplinary University Research Initiative awards at multiple universities.

IMPORTANCE OF MAINTAINING BASIC RESEARCH AND APPLIED RESEARCH

2. Senator PERDUE. Dr. Griffin, while accelerating development of new technologies is often framed in terms of prototyping and demonstrations of mature capabilities, it is also important for the U.S. to continue to invest in long-term scientific research, DOD's 6.1 basic research and 6.2 applied research, in order to be prepared for future threats and continue to maintain our high-skilled scientific workforce. What is the importance of maintaining a balance and ensuring continued support for 6.1 basic research and 6.2 applied research?

Dr. GRIFFIN I will support continued robust funding for basic and applied research in our 6.1 and 6.2 budget portfolios. The Department's past investment in basic research has been the foundation for many of the disruptive technologies utilized by our military and civilians today. While basic research attracts the brightest scientific minds to the fundamental questions in the Department's fields of interest, applied research allows those minds to begin to utilize that fundamental knowledge to address particular national security challenges. Additionally, early-stage research projects are a means to train students in fields essential to maintaining our future Defense workforce. Robust applied research funding helps to more quickly prototype and provide options to programs of record to meet defense needs. While the Department places a strong emphasis on delivering new technologies in the near term, we must also not lose sight of longer term challenges that basic and applied research address.

QUESTIONS SUBMITTED BY SENATOR TED CRUZ

SMALL LAUNCH

3. Senator CRUZ. Dr. Griffin, as you know, much of our warfighting advantage resides in the strength and capability of our space-based satellite assets. However, our adversaries are quickly catching up in terms of both their own satellite constellations and their ability to threaten and degrade our own space capabilities. The need for new responsive access to space and diffuse constellations to improve resiliency has been noted by many experts both inside and outside government. However, until very recently, the United States has not had many options to efficiently and affordably put such small sat constellations into space, not to mention in the case

of need of rapid re-constitution in the face of conflict. Over the last several years, new U.S. small launch systems have been developed, including companies like Firefly Aerospace in Texas.

Can you describe for us how small launch fits into DOD's list of needed next generation capabilities and how is DOD supporting the emerging U.S. small launch providers? What more can be done to support and perhaps accelerate the development and fielding of this technology? And how can we on-ramp these capabilities more quickly and tap into new innovations from small launch providers?

Dr. GRIFFIN DOD space access capability is provided through Evolved Expendable Launch Vehicle. Alternative small launch capability would be procured through the private sector. FMR 7000.14–R, Vol 11A, Ch 13 allows U.S. private sector use of DOD space related facilities, including Major Range and Test Facility Base, at direct costs accrued in supporting the commercial space activity. "Direct costs" are the actual costs that are directly attributable to the use of the facility, over and above the indirect costs. This enables small launch providers access to an existing broad range of space related facilities and range infrastructure.

QUESTIONS SUBMITTED BY SENATOR JEANNE SHAHEEN

COLD WEATHER CONFLICT RESEARCH

4. Senator Jeanne SHAHEEN. Dr. Griffin, the personnel at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, New Hampshire conduct valuable research with the goal of improving the readiness of the U.S. military by enhancing its ability to effectively operate in cold weather environments. What is the status of DOD cold weather-related research, as well as your assessment of its importance in preparing our forces to operate in such an environment?

Dr. GRIFFIN The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) conducts research on cold region dynamics to provide both on-site engineering solutions and strategic problem-solving for the future. CRREL focuses particularly in the areas of terrain composition (with a focus on permafrost), infrastructure stability and resiliency, and testing for equipment and platforms intended for cold weather use. They conduct their work in partnership with other DOD stakeholders such as the Office of Naval Research, the U.S. Army Institute for Environmental Medicine, and the Navy's Experimental Diving Unit. This is a joint effort to further DOD's cold-weather capabilities. Recently, my office and USNORTHCOM hosted a workshop with researchers, service members, and Arctic professionals, where they discussed priority requirements, current S&T investments, and gap areas. This workshop underscored how existing investments are critical enablers for military training, exercises, and operations that could occur in high-altitude environments, the Arctic, and other areas characterized by extreme cold or winter weather.

SMALL BUSINESS

5. Senator Jeanne SHAHEEN. Dr. Griffin, as you know, small businesses in this country are the engines of innovation and job growth. The Senate Armed Services Committee has routinely heard that the Small Business Innovation Research (SBIR) program is an essential mechanism for DOD to develop new technologies that help the warfighter and support our national defense. One of the criticisms that is often made of the defense research enterprise is that new technologies do not transition in an effective or efficient manner. There does not seem to be an effective mechanism to transition a program of record or transfer to a private sector firm. How does the SBIR program help to transition technologies to, ultimately, get them to our warfighters—and do you agree that SBIR should be made permanent?

Dr. GRIFFIN The SBIR program seeds and grows technology options for consideration by Programs of Record and our Prime Contractors. The SBIR program seeks to mature technologies and reduce the development risk as much as possible. However, SBIR is a Research & Development program and by that nature, many technologies never mature to a level that enables them to be transitioned.

Yes, SBIR should be made permanent.

Making these programs permanent would allow for consistency and remove uncertainty about the long-term support for this critical driver of innovation for DOD and job growth for the country. Permanency also improves the ability for the DOD consumers of SBIR/STTR technology solutions (programs of record, PEOs prime contractors and others) to plan for technology integration and insertion.

TECHNOLOGY TRANSITION SPEED

6. Senator Jeanne SHAHEEN. Dr. Griffin, I am a member of the Senate Appropriations Committee. Are there changes to the appropriations rules, as well as other budgeting and financial management tools, which could be used to speed up technology transition?

Dr. GRIFFIN Part of maintaining our technological advantage is not only promoting aggressive technology investments but also transition them into capabilities at a speed of relevance. Adequate funding flexibilities for these types of efforts remains a challenge.

The new statutory authorities associated with "middle-tier acquisition pathways" (Fiscal Year 2016 NDAA Section 804 Rapid Prototyping and Rapid Fielding) and the Acquisition Agility Act (AAA) (fiscal year 2017 NDAA sections 805–809) will help technology and prototype transition, however, dedicated funding for these new rapid prototyping/rapid fielding authorities has not been appropriated to date. A flexible funding account for integration, experimentation, and testing in support of transitioning successful technologies and prototypes into major acquisition programs would also assist.

Another challenge associated with transition of successful technologies into a program is the impact on the program baseline. Rapid response to unexpected threats or game-changing technology can in some cases drive costs that may breach the initial acquisition program baseline. Although the intelligence, requirements, and acquisition communities cooperate to identify and address threats, it is impossible to be fully predictive. Amending Nunn-McCurdy breach language could avoid penalizing programs trying to incorporating new technologies. Exempting major acquisition programs that successfully incorporate a modular, open systems approach (fiscal year 2017 NDAA section 805) will enable these programs to incorporate new technology without additional administrative overhead.

QUESTIONS SUBMITTED BY SENATOR KIRSTEN GILLIBRAND

USE OF DEFENSE PRODUCTION ACT FOR SCALING UP PRODUCTION OF DEFENSE TECHNOLOGIES

7. Senator GILLIBRAND. Dr. Griffin, far too many American start-ups working on cutting-edge technologies with applications important to our defense mission are having a difficult time accessing investment to scale their research to production. This financing gap has led some of our most innovative firms to turn to foreign investors, which offshores production and undermines our ability to protect military technologies. What role do you think the Department of Defense might play in addressing this national security challenge?

Dr. GRIFFIN A healthy manufacturing and defense industrial base is essential to the economic strength and national security of the United States. DOD will continue to seek to capture and transition innovative ideas into military capabilities. In addition to the Defense Innovation Unit Experimental (DIUx), which seeks to bridge the gap with start-ups, DARPA is providing its Program Managers with mentoring and support to help them navigate the venture capital world and increase the likelihood of transitioning ideas into commercially viable product. I will seek to increase DOD's engagement with all sources of innovation, as these software and hardware start-ups underpin our modernization priorities.

8. Senator GILLIBRAND. Dr. Griffin, could the Defense Production Act's Title III financing authorities be put to greater use for helping scale up production of defense technologies?

Dr. GRIFFIN The Under Secretary of Defense for Acquisition and Sustainment (USD(A&S) provides oversight on behalf of the Secretary of Defense for the Defense Production Act Title III. I support her efforts to expand the program by utilizing the full breadth of the authorities, including loans and purchase commitments, and make the program nimble by leveraging military services or field agencies in the execution Title III projects that address their identified critical technology needs. Further, I strongly support her efforts to remove the $50 million cap on each Title III project and the $133 million/yr limit on DPA Title III appropriations as it allows DPA Title III to address capital intensive follow-on commercialization projects to Research and Engineering efforts like strategic radiation hardened microelectronics and hardware integrity and security projects that can total well over $50 million.

9. Senator GILLIBRAND. Dr. Griffin, will you commit to looking with my staff at the issue of the potential role of the Defense Production Act's Title III financing authorities in scaling up production of defense technologies?

Dr. GRIFFIN I will work with your staff as appropriate to identify the Department's opportunities to scale up production of defense technologies.

MANUFACTURING USA'S ROLE IN DEFENSE PRODUCTION

10. Senator GILLIBRAND. Dr. Griffin, I believe the Manufacturing USA Network is critical to ensuring the United States remains a global leader in manufacturing the cutting-edge technologies needed for our national defense. Part of this bipartisan program's mission is to use these public-private partnerships to develop and commercialize new defense technologies that are critical to our men and women in uniform, like 3D printing and smart sensors. As you know, the Defense Department is leading 8 of the 14 current institutes within the network, including one focused on integrated photonics located in Rochester, NY. Now that you have been on the job for two months, what plans do you have in mind for how the Manufacturing USA network can be used to strengthen our defense production capacity, including preparing our workforce with in-demand skills for advanced manufacturing, accelerating technology transition, and assisting our startup companies and small manufacturers in scaling up production?

Dr. GRIFFIN The Manufacturing USA Network of 14 innovation institutes is in the midst of a successful initial operating phase, developing capability of importance to the Department. Continued DOD involvement in the Manufacturing USA Network protects are equities and enables further development of defense critical technologies into affordable, domestic defense products across fourteen broad technology areas, eight of which we have co-sponsored. To date, the DOD has invested over $600 million to establish key innovation hubs for additive manufacturing; digital manufacturing, design and cybersecurity; lightweight and modern metals; integrated photonics; flexible hybrid electronics; revolutionary fibers and textiles; regenerative tissue manufacturing; and advanced robotics. The state-of-the-art integrated photonics test, assembly and packaging facility is opening soon in Rochester, NY and is a great example of the collaborative manufacturing innovation ecosystems the DOD and in this case, the New York state government which is also investing to strengthen both commercial and defense production capabilities. Long term engagement with the Manufacturing USA Network will allow DOD to reap the benefits of these substantial investments in pre-competitive, applied R&D. Manufacturing USA constitutes a key component of the SECDEF's vision of a National Technology Innovation Base. The advanced manufacturing ecosystem development and collaboration that these institutes foster helps ensure that key advanced technologies that are invented here are manufactured here. Together with our agency partners at DOE, DOC (NIST), NASA, USDA, DOL, and DoEd, we will continue to engage with small and medium sized manufacturers, identify scale-up opportunities important to DOD needs, accelerate technology transition domestically, and help train the advanced manufacturing workforce of the future.

TECHNOLOGY ACCELERATOR AND TRANSFER PROGRAMS

11. Senator GILLIBRAND. Dr. Griffin, the Department of Defense's MD5 National Security Technology Accelerator located at New York University is building a national network of civil-military partnerships in technology R&D to support entrepreneurs both within and outside of DOD in successfully developing, commercializing, and applying technology relevant to the military. Do you see an expanded role for MD5 in addressing the "valley of death" concerns faced by our military?

Dr. GRIFFIN Like most of our innovation program offices, MD5/NSTA is providing real value, both to the Department and the broad array of non-traditional partners with whom it interacts. Although I believe the Department needs to evaluate MD5/NSTA as part of a broader, holistic discussion related to program priorities and attendant resources, I believe MD5/NTSA is a key player in addressing, and hopefully eliminating, the "valley of death" and delivering crucial new technology to the warfighter. I plan to ensure that MD5/NSTA is organized with mutually supporting innovation programs as I finalize the organizational structure of the new Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) to enhance the scope, capabilities and mutually supporting efforts of MD5/NSTA and other defense innovation entities.

12. Senator GILLIBRAND. Dr. Griffin, recently the Advisory Panel on Streamlining and Codifying Acquisition Regulations, otherwise known as the section 809 Panel, made a series of recommendations for how to strengthen the Small Business Innova-

tion Research and Small Business Technology Transfer (SBIR–STTR) and the Rapid Innovation Fund (RIF) Programs that are vital to technology research, development, and commercialization. Do you believe the Defense Department is making full use of the SBIR–STTR and RIF programs to leverage small businesses in advancing the development and production of technologies?

Dr. GRIFFIN I think the Department is making full use of the SBIR/STTR and RIF programs within the current limitations of the law. However, three changes would certainly allow the Department to make better use of the SBIR and STTR programs: (1) make the SBIR and STTR programs permanent; (2) remove the restriction against using SBIR or STTR funds for administrative purposes and (3) restore and make permanent the Phase Flexibility (also known as 'Direct to Phase II') provision, which provides the ability to shorten the development cycle for critical technology solutions.

I will continue to review the current programs to identify opportunities for improvement to ensure we utilize these programs effectively to advance the development and production of technologies.

13. Senator GILLIBRAND. Dr. Griffin, what reforms do you believe are needed to strengthen the SBIR–STTR and RIF programs to help small companies and entrepreneurs commercialize technologies and get them into the Defense Department's acquisition pipeline?

Dr. GRIFFIN The SBIR and STTR programs support our ability to work with small business across the nation to develop cutting edge solutions for difficult problems facing our warfighters. As stated earlier, restoring the Phase Flexibility, or Direct to Phase II, authority would help small companies and entrepreneurs step into the process closer to commercialization. This authority did shorten the development time for technologies to transition to Phase III funding and encourages companies with more mature technologies to participate in the program, further enhancing the technical solutions available to DOD. As an example, the Air Force used this authority to develop new technologies to leverage commercial satellite imagery and to develop new hand-held devices for dismounted navigation in a GPS-degraded environment.

Another change would be to allow DOD Components to award additional Phase II efforts, beyond the current limit of two per topic per small business, on topics developed by other Federal Agencies or DOD Components. Components have become effective taking technologies developed by others and adapting them for their own requirements to reduce costs, time and risks. This change would allow DOD Components to make better use of limited budgets to support their customers.

QUESTIONS SUBMITTED BY SENATOR MARTIN HEINRICH

DIRECTED ENERGY

14. Senator HEINRICH. Dr. Griffin, thank you for your comments at the hearing on the need for the Department to "persist" with regards to directed energy weapons in order to cross the threshold from R&D to procurement. I agree, and I want to restate the following points I made at this year's 2018 Directed Energy Summit, which I believe are critical for transitioning these technologies.

We need senior level officials at the Pentagon to identify capability gaps and know where directed energy can be a solution. We need senior officials at the Pentagon to help push the Joint Requirements Oversight Council and the military services to recognize the benefit of directed energy weapon systems when they write military requirements. We need senior level officials at the Pentagon to take ownership of directed energy in budget deliberations and program funding battles. And we need senior level officials to speak up for directed energy when Analysis of Alternatives are occurring.

As the DOD Senior official for directed energy, what near-term actions will you take to potentially increase investment and speed transition of directed energy weapon systems?

Dr. GRIFFIN The Department is making every possible effort to field DE capabilities; however, we cannot field these capabilities before they are ready, which includes having a mission, or a range of missions, where DE provides the competitive advantage to our warfighter. Over the past year, AT&L and CAPE jointly went through an assessment of current state of the art in High Energy Lasers (HEL) as a capability to do a variety of missions. We continue to reassure all the stakeholders that DOD has a pretty good understanding of where we stand in both the technology and the mission space. As a result of our analyses, we are initiating new ef-

forts to scale up electrically powered lasers to levels that do not currently exist. In standing up the Office of USD(R&E), we are having productive engagements with all stakeholders, and looking to a future where DE weapons including High Power Microwaves are a reality that supports the missions that provide competitive advantage to DOD. We must be partners in building an industrial base capable of building and delivering critical components affordably and timely to accelerate the fielding of these systems.

15. Senator HEINRICH. Dr. Griffin, as you know, this committee recently designated the Joint Directed Energy Transition Office and established a new prototyping and demonstration program at the pentagon, of which you will be in charge, to accelerate the transition of directed energy weapons. As the Senior Official with responsibility for transitioning directed energy weapon systems, who in your organization will handle the directed energy testing and transition?

Dr. GRIFFIN As we fully implement the reorganization plans, I will have oversight of the entire spectrum for research and development. The Joint Directed Energy (DE) Transition Office will continue to focus on basic and applied research to develop fundamental technologies necessary for our DE systems. The components will perform the prototyping and experimentation with support from my office to validate we are building the capabilities we need, at the costs we can afford, and with the agility and speed necessary to meet the warfighter requirements. As part of the directed designation, the transition office will assist the components in transitioning those validated capabilities.

16. Senator HEINRICH. Dr. Griffin, what role does the newly designated Joint Directed Energy Transition Office play within your portfolio and how will you resource that office?

Dr. GRIFFIN As I described earlier, the Joint DE Transition Office will provide oversight and synchronization of the fundamental technologies needed to build our systems, provide support to the Components in the prototyping and experimentation efforts, and support the transition of capabilities that demonstrate their readiness to transition into programs of record. I would like to emphasize, transitioning these systems also require support from the industrial base. We must be partners in building and delivering critical components affordably and timely to accelerate the fielding of these systems.

17. Senator HEINRICH. Dr. Griffin, this year's budget request refreshed a heritage PE for High Energy Laser Advanced Development, requesting $69.53 million for PE 0603924D8Z. Who within the DOD would be the executing agent for this line?

Dr. GRIFFIN This PE will be managed and executed out of my office starting in fiscal year 2019. There is a proposed fiscal year 2018 Enhancement in response to the Bipartisan Budget Act of 2018 for $36 million. This program complements, and is closely coordinated with, other DOD HEL efforts directed at specific Service and Agency missions. This effort will scale the output power of HELs to reach operationally effective power levels applicable to broad mission areas across the DOD and pursue improvements in common HEL system components, such as efficient laser pump diodes for increased electrical-optical efficiencies and efficient light-weight thermal management approaches and/or power supplies.

18. Senator HEINRICH. Dr. Griffin, what are your plans for the position of Assistant Secretary of Defense for Research and Engineering?

Dr. GRIFFIN The Secretary of Defense will soon make the final decisions on the detailed implementation plan for the reorganization of the office of the Secretary of Defense, and specifically the split of the USD(AT&L). I would like to avoid getting ahead of the Secretary and his communication with this committee and other members of Congress on the specifics of that plan, but I can share that the responsibilities of the ASD(R&E) will transition to the new offices we are establishing. Our emphasis on separating research and technology, and advanced capabilities will focus the efforts across the spectrum from science and technology, to prototyping and experimentation.

19. Senator HEINRICH. Dr. Griffin, what is the status of the Joint Directed Energy Test Center report?

Dr. GRIFFIN The report has been completed by the Test Resource Management Center and is under review. Upon review completion, it will be submitted to the Senate Armed Services Committee.

ROLE OF DEFENSE LABS

20. Senator HEINRICH. Dr. Griffin, the 2017 Defense Science Board study on the Defense Research Enterprise noted that "The DOD Labs contain the bulk of technology and engineering expertise of the Department, almost 40,000 scientists and engineers. This is the core muscle the Department has to create, transition, and deploy technology to the warfighter."

How do you plan to use the Labs to lay a bigger role in rapid technology transition of both defense-unique and commercially available technologies into defense acquisition programs or operational use?

Dr. GRIFFIN The DOD laboratory enterprise and our scientists and engineers are the core of our research and development programs. The work they are doing for our warfighters is having an impact on capability development. We must continue to enable rapid technology transition by focusing on prototyping, experimentation, and demonstration processes to ensure effective dialogue between the research and development enterprise and the acquisition programs of record. Recent authorities in fiscal year 2016 and 2017 NDAAs provide pathways to prototyping technologies outside programs of record, which enable much more rapid assessment of viability and a greater opportunity to leverage the expertise of the DOD Labs. Close dialogue and coordination by our laboratories, acquisition community, and private sector is necessary for expeditious deployment of new technologies in the face of an ever-changing battlefield environment for our Warfighters.

ROLE OF FUNDING AND BUDGETING PROCESSES

21. Senator HEINRICH. Dr. Griffin, in terms of the defense budget and Congress, the way we appropriate funds is no way reflective of the speed at which threats and technologies move. Too many good ideas die on the vine while waiting for DOD to get the right money into the right account, with the right rules according to various financial management and appropriations laws and regulations.

What changes would you recommend both to slow-moving DOD budgetary processes and to congressional procedures that might help speed up technology transition processes, while still preserving accountability and transparency that taxpayers deserve?

Dr. GRIFFIN The two-year planning and programming budget cycle does not lend itself to support rapid transition of successful technology into capabilities because of the inherent uncertainty. Results of an S&T effort are unpredictable; therefore, budgeting for a transition pathway is difficult. An efficient, flexible, and expedient means to re-align funds within an organization would alleviate this issue.

To enable the Department to take advantage of innovative technologies and effectively transition them to the warfighter in a timely manner, flexible funding accounts for rapid prototyping, experimentation, integration, and testing should to be appropriated at both the Department and Service levels. This will enable the Department to bypass the slow-moving DOD budgetary processes. Flexible funding accounts could speed up the transition and fielding of successful and promising technologies.

Below threshold reprogramming (BTR) limits are also barriers for technology transition. Current BTR limits restrict Service program sponsors ability to test, integrate, and procure new major components for a program of record. Modifying the current BTR language to increase the limits would allow the restructuring of the program to integrate, test, and field improved performance upgrades much sooner. Conversely, waiting for formal Congressional reprogramming or traditional budgeting procedures could delay these upgrades by up to two years. Additional reporting mechanisms in Fiscal Year 2017 NDAA Acquisition Agility Act which will ensure Congress and the Department leadership are aware of impending program changes.

In addition, my organization is completing an assessment in support of the fiscal year 2018 NDAA section 232 "Review of Barriers to Innovation in Research and Engineering Activities of the Department of Defense." We may have additional recommendations to financial management and budget barriers to technology transition.

NATIONAL MATH & SCIENCE INITIATIVE'S COLLEGE READINESS PROGRAM

22. Senator HEINRICH. Dr. Griffin, I recently visited Cannon Air Force Base where I heard about the National Math & Science Initiative's College Readiness Program. This program aims to improve the quality of school districts that serve military installations by training teachers to teach STEM AP exams. The program increases the number of students taking those classes and more than doubles the rate of

qualifying scores. This helps military installations retain their personnel by making sure local schools are serving military families well. The communities benefit because by focusing on teacher training, the program benefits all students, not just DOD dependents. While the program has been implemented in one thousand schools, only one such program has run in NM, at Alamogordo High School. I am excited to see this program come to qualifying schools that serve White Sands Missile Range and Cannon High School. What will your office do to increase the number of students this program can reach?

Dr. GRIFFIN The Department of Defense partnered with the National Math and Science Initiative (NMSI) since 2009 to reach military-connected high schools to enhance the preparation of military children for careers in STEM through AP math and science courses. NMSI's College Readiness Program (CRP) has been implemented in 217 military-connected schools serving 93 military installations to date. In the 2018–19 academic year, DOD will support the implementation of the CRP in 19 new military-connected high schools across the Nation. The Department continues to consider the viability of the NMSI program in addition to other efforts supporting military children to maximize their impact. Although the 2018–2019 cohort does not include any qualified schools serving White Sands Missile Range or Cannon High School they could be considered as part of a future implementation of the program.

BASIC RESEARCH

23. Senator HEINRICH. Dr. Griffin, what is the role of university research and investment in basic science in supporting our technological superiority? What areas of basic research are you worried about in terms of underfunding within the U.S.?

Dr. GRIFFIN Basic research investments answer fundamental scientific questions which can lead to groundbreaking discoveries, providing the foundation for future defense-related technologies. The Department recognizes that much of this discovery is made by the academic community. In fact, the Department is now the third largest investor of basic science funding at universities. I believe it is critical to engage with the academic community to build on this partnership so that universities better understand the Department's needs and to leverage these groundbreaking research findings. While I believe that robust funding for basic research is needed across the scientific disciplines, I particularly support basic research funding in areas that provide the foundations for the Department's technological priority areas including but not limited to artificial intelligence, quantum information science, research setting the foundations for hypersonics, future computing capabilities, materials science, synthetic biology, oceanography, and social science. Research programs in these areas are critical to supporting the Department's superiority.

DEVELOPMENTAL TEST & EVALUATION AND TEST RESOURCE MANAGEMENT CENTER

24. Senator HEINRICH. Dr. Griffin, what are your plans to support your office's Development T&E staff and the TRMC to support your efforts in maintaining our ability to deliver operational capabilities as quickly as possible?

Dr. GRIFFIN I strongly agree we need to deliver operational capabilities quickly. Both the Developmental T&E staff and the TRMC are dedicated to this goal. Here are some of the specifics of my plan to accomplish this.

The Developmental T&E Staff is committed to a "Shift Left" test approach concentrating on collecting and evaluating test data as early as possible in the acquisition process to reduce late discovery of deficiencies and the costly need for re-design. Key to this effort is the development and approval of the Test and Evaluation Master Plan (TEMP), which DT&E and DOT&E work in collaboration with the program offices to build. The TEMP lays out the strategy for testing weapon systems and identifies the test infrastructure and capabilities necessary to achieve that goal. The DT&E staff work closely with the programs to ensure: 1) test activities are integrated into the schedule as early as possible, 2) contractor and other test data is used where possible to reduce duplicative testing, 3) joint DT/OT events are maximized to further reduce duplication and test costs, and 4) test feedback is shared with the program offices as early as possible. DT&E also works closely with counterparts in the TRMC to ensure any test infrastructure limitations or test needs are identified clearly in the TEMP.

The Test Resource Management Center is an important organization for ensuring the DOD's T&E workforce and infrastructure are modernized and ready to support the testing of our weapon systems. TRMC continually anticipates T&E infrastructure needs early in the acquisition process through its collaborative strategic planning process with the Services and OSD components and develops test infrastructure roadmaps to highlight key deficiencies that need to be addressed to support up-

coming programs of record. Previous roadmaps have been key to the early resourcing of T&E capability gaps in electronic warfare testing, hypersonic ground testing, and threat models. New roadmaps will address further T&E shortfalls in Hypersonic open air testing, Cyber effects testing, EW threat integrated air defenses, big data concepts, and others.

In addition to planning, the TRMC also manages 3 key programs to ensure the test infrastructure is ready to support testing of our most advanced weapons systems. TRMC's Test and Evaluation/Science and Technology (T&E/S&T) Program matures test technologies from TRL 3 to TRL 6 so they can be transitioned into T&E capabilities in our test ranges around the country. The T&E/S&T program looks forward at the advancement of the Department's acquisition programs and technology demonstrators to anticipate technologies needed to test our next generation weapon systems. Technology transition rates for the program are well in excess of 50 percent due to the tight coupling of the technology maturation efforts and the work that is done to ensure test infrastructure projects are aligned to integrate them. A particularly relevant example is the $100 million plus of investments T&E/S&T made over the past decade to prototype test capabilities key to advancing DOD hypersonic programs. T&E/S&T was the forerunner in developing a hypersonic test roadmap and it was due to these efforts and investments the TRMC was able to secure $350 million via a Resource Management Decision (RMD) to implement these technologies on our test ranges. The technologies matured by the T&E/S&T program are now being inserted and implemented at Arnold Engineering Development Center to produce ground-based test capabilities absolutely critical to fielding hypersonic weapon systems. Due to the forward looking nature of the TRMC and the timeliness of these key investments, the Department will save billions of dollars and years of schedule in developing hypersonic weapon systems.

The TRMC fields major test instrumentation to the Services' test ranges via the Central Test and Evaluation Investment Program (CTEIP) which focuses on developing high priority multi-service T&E capabilities. As technologies are matured via the T&E/S&T program, CTEIP adopts those technologies to field needed test capabilities. As the Department looks for ways to accelerate the acquisition of weapon systems, the TRMC also seeks to accelerate the process by which test capabilities are fielded as the T&E community must constantly keep pace and, in many cases, lead the development cycle. Over the past several years, CTEIP has begun using more streamlined acquisition approaches such as those offered under the Defense Ordnance Technology Consortium (DOTC) and Other Transaction Authorities (OTAs) to speed contracting and development processes. These approaches have worked well for CTEIP and have enabled the TRMC to field test capabilities to the Services as much as three times faster than traditional contracting approaches. Additionally, these strategies have enabled TRMC to be much more responsive to the fast moving world of cyber threats and have provided a much quicker reaction time for responding to unanticipated critical operational test shortfalls identified by DOT&E. Under my leadership, the TRMC will continue to pursue streamlined acquisition approaches like these as a ready and adequate test infrastructure is absolutely critical for testing and fielding DOD weapon systems.

Lastly, the use of distributed testing has proved to save both time and money for the Department and avoids the Services from building duplicative capabilities across the country. The TRMC operates a third program, the Joint Mission Environment Test Capability (JMETC), to maximize distributed testing capabilities by connecting existing laboratories, hardware in the loop facilities, installed system test facilities, and open air range capabilities around the country. JMETC and the TRMC establish standards and develops common interfaces, promoting interoperability and enabling maximum re-use of the Department's key test facilities. Test resource dollars are limited and the TRMC maximizes those resources by encouraging the development and adherence to those standards which ultimately avoids duplication, reduces test time, and makes test capabilities more sustainable.

FOREIGN STUDENTS

25. Senator HEINRICH. Dr. Griffin, many foreign students study in STEM fields in this country and could potentially contribute to national goals, but they often are forced to return to their home country because of visas or because of an increasing number of good employment options overseas and in their home countries. In fact, many of these students are funded by DOD grants and research programs. How can DOD appropriately make better use of the foreign STEM talent that is studying and working in the U.S.?

Dr. GRIFFIN The Department has long benefitted from the talents of foreign students and some of the best minds in the world that come to the U.S. to work with

other top scientists. Foreign graduate students contribute to our economy, teach our undergraduates, and make impressive research discoveries here in the United States. The Department should continue to identify and hire the best and brightest minds from around the world to address fundamental research challenges of interest to our national security. Maintaining strong, stable funding for defense research is part and parcel to our success in this mission. We need to work with the State Department, the academic community and other stakeholders to identify ways we can take advantage of the tremendous talent educated in the U.S. while maintaining a reasonable balance to avoid unintended transfer of research and knowledge on critical technology areas important to the Department.