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PROMOTING DOD'S CULTURE OF INNOVATION

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ONE HUNDRED FIFTEENTH CONGRESS

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PROMOTING DOD'S CULTURE OF INNOVATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
Washington, DC, Tuesday, April 17, 2018.

The committee met, pursuant to call, at 10:01 a.m., in room 2118, Rayburn House Office Building, Hon. William M. "Mac" Thornberry (chairman of the committee) presiding.

OPENING STATEMENT OF HON. WILLIAM M. "MAC" THORNBERRY, A REPRESENTATIVE FROM TEXAS, CHAIRMAN, COMMITTEE ON ARMED SERVICES

The CHAIRMAN. The committee will come to order.

For the last three National Defense Authorization Acts, reform, especially acquisition reform, has been a major priority. The purpose is to get more value for the taxpayers out of the money spent, but, even more importantly, to make the Department more agile in dealing with the variety of security challenges we face.

As Secretary Mattis has testified, our technological position has eroded in recent years, compared with our leading adversaries. We confront threats that do not conform to our traditional notions of warfare. And the historical evidence indicates that we may well be a victim of our own success. As one writer put it, when looking at the interwar years, the losers were forced by events to reexamine everything. Military losers are intellectual radicals. The winners, complacent in victory, feel the need for self-examination far less.

The answer is the Department of Defense must work to be more innovative in technology, in policies, and in thought. One of the many books offering advice to businesses sums it up with a chapter title that is "Innovate or Die." That has been the goal of the reforms of recent years and of the reform proposals for the fiscal year 2019 NDAA [National Defense Authorization Act] that I am releasing today.

We are privileged to have two witnesses who are superbly qualified to help guide our efforts as well as those of the Department in the quest to develop a culture of innovation. One of the reforms we enacted 2 years ago was to create an Under Secretary of Defense for Research and Engineering, to be the primary driver of innovation in the Department. Dr. Michael Griffin was confirmed in that position about 2 months ago and, among other things, is the former administrator of NASA [National Aeronautics and Space Administration].

Dr. Eric Schmidt is the chairman of the Defense Innovation Board, and formerly chairman and chief executive officer of Google and its parent Alphabet, where he remains a technical adviser. He

is here, however, only in his capacity with the Defense Innovation Board.

We are very grateful to have both of you here. I might alert members that immediately after this open hearing, we will reconvene in classified session to go in greater detail about some of these issues.

Let me at this point yield to the gentlelady from California, who is the acting ranking member.

[The prepared statement of Mr. Thornberry can be found in the Appendix on page 43.]

STATEMENT OF HON. SUSAN DAVIS, A REPRESENTATIVE FROM CALIFORNIA, COMMITTEE ON ARMED SERVICES

Mrs. DAVIS. Thank you, Mr. Chairman. And I want to ask unanimous consent to put the ranking chair statement into the record.

The CHAIRMAN. Without objection.

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

Mrs. DAVIS. Thank you. I certainly appreciate the chairman's calling today's hearing on the need for more innovation and technology development in the Department of Defense. And we are honored to have both of you here today to serve as witnesses on this critically important topic. We have been talking about it for a long time, but actually addressing it in a way that is going to continue to make a difference is part of, really, what we want to see happen.

Maintaining a culture of innovation does matter. Innovation ensures our service members have the technological edge they need. Innovation has the power to win tomorrow's wars before they are fought. We must continue to promote a culture of openness, looking for new ways to do things, being willing to accept prudent risk in trying something different, and constantly looking ahead rather than behind.

But we also know that the Department of Defense cannot go it alone. They must work with the private sector and academia. No less important are investments in STEM [science, technology, engineering, and math] education, programs that develop junior talent into future tech leaders and policies that promote an environment in which global collaboration, discovery, innovation, public institutions, and industry can thrive.

I had an opportunity to read Dr. Schmidt's statement, and I want to thank you, because it provides a kind of reality test for us and how do we continue to do many of the advances that we have been working on, and you note those in your statement very clearly, but also, build an architecture that is going to bring us into the future, and certainly respond to the needs of the men and women who go to war on behalf of our country.

I look forward to hearing your testimony today. Thank you.

And I, excuse me, and I yield back.

The CHAIRMAN. Without objection, both of your written statements will be made a part of the record.

I do want to comment, Dr. Griffin, that nobody has read yours, because we just got it. And I think it is important—I realize that when you are an administration official, it has got to be cleared by all of these different levels, but whatever the administration, it is

important for those involved in getting us written statements to get them timely, or else there is just really no use in doing it.

And, again, nobody has read your statement, because I think it just came at some point this morning. I am not fussing at you, but I am fussing at all those layers that are responsible. It is kind of a good summary of our acquisition problems. If you got all these layers of people that have to approve something, it takes a long time to get something, and maybe that is an appropriate analogy for the innovation topic today.

But, without objection, your full written statements will be made part of the record. We are grateful to both of you for being here.

And Dr. Griffin, the floor is yours.

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

Secretary GRIFFIN. Thank you, Mr. Chairman.

First of all, my apologies. The statement is late, and the error is mine, and no other excuse is permissible.

So, moving forward, Chairman Thornberry, Ranking Member Smith, Acting Ranking Member Davis, and members of the committee, I do appreciate your entering my written statement in the record and I want to thank you for the opportunity to discuss ways that we, as the Department of Defense, can foster a culture of innovation throughout the Research and Engineering Enterprise.

The reality is that we live in a time of global access to technology and global access to scientific talent. It is no longer preeminently concentrated here in America. The air, land, sea, space, and cyber domains have all experienced dramatic capability advances, and have done so throughout the world. These advances, coupled with our adversaries' commitment to a demonstrated pace of prototyping and experimentation and fielding that, at present, far outstrips our own pace, present a formidable challenge to U.S. forces operating around the globe.

It is this erosion of U.S. technological superiority that led to the establishment of the position which I now hold as Under Secretary for Research and Engineering. Our mission is to ensure that we maintain our technological edge, and I am honored to be here today to talk with you about that.

I believe that I come to this position reasonably well-versed in the threats that face the United States today, and I am indeed concerned. We are in a constant competition. In a world that has now equal access to technology, innovation will remain important always, but speed becomes the differentiating factor. Greater speed in translating technology into fielded capability is where we can achieve and maintain our technological edge. We must seek innovation not only in our technology, but in our processes. I look forward to instilling within the Department a culture that embraces a more agile approach to development.

Now, with that said, I would be remiss if I did not highlight the DOD R&E [Department of Defense Research and Engineering] Enterprise, which consists of our labs, our engineering and warfare centers, and our partners in the FFRDCs [federally funded research and development centers], UARCs [university affiliated re-

search centers], academia, and industry, both small and large business, who have given us the military capabilities that we enjoy today, and that will give us the ones we will need in the future.

The Department is addressing critical technology and capability gaps through a combination of adaptation of existing systems and the development and introduction of innovative new technologies through our labs and centers and DARPA [Defense Advanced Research Projects Agency] and other entities.

The Department continues to push the envelope with research into new technologies, such as autonomous and unmanned systems, artificial intelligence, machine learning, biotechnology, space technology, microelectronics, and cyber, both offense and defense.

These technology areas are not just important to the Department, they are the focus of global industry. And we are focused not just upon technological innovation, but also upon pursuing new practices and organizational structures to support this culture of innovation. Earlier this year, Deputy Secretary of Defense Shanahan said, and I quote: "Everyone wants innovation, but innovation is messy. If the Department is really going to succeed at innovation, we are going to have to get comfortable with people making mistakes."

From my own background of producing experimental hardware when I had possibly more enjoyable jobs, I can certainly say that no progress is possible without the willingness to take chances and make mistakes with today's hardware in order that tomorrow's systems will be better.

We are, today, making investments across the full spectrum of innovation. These areas include early stage research and development, repurposing commercial and nontraditional technologies for national security purposes, the advancement of manufacturing technologies, red teaming to identify our own vulnerabilities, new technology demonstrations, and experimentation and prototyping. Our adversaries are presenting us today with a renewed challenge of a sophisticated, evolving threat. We are, in turn, preparing to meet that challenge and to restore the technical overmatch of the United States Armed Forces that we have traditionally held.

I thank you again for the opportunity to testify on this critical issue, and I look forward to your questions. Thank you, sir.

[The prepared statement of Secretary Griffin can be found in the Appendix on page 45.]

The CHAIRMAN. Thank you, although I cannot imagine a job that would be more enjoyable than the one you have now to help the Department of Defense be more innovative.

Dr. Schmidt, thank you for being here.

STATEMENT OF DR. ERIC SCHMIDT, CHAIRMAN, DEFENSE INNOVATION BOARD, DEPARTMENT OF DEFENSE

Dr. SCHMIDT. Thank you, Mr. Chairman. I completely agree with——

The CHAIRMAN. I might get you to—yeah, hit the button, please.

Dr. SCHMIDT. Sorry.

Thank you, Mr. Chairman. And I completely agree with what Dr. Griffin just said. I think it is crucial for our Nation. I have worked with a group of volunteers over the last couple of years to take a

look at innovation in the overall military, and my summary conclusion is that we have fantastic people who are trapped in a very bad system. And I am concerned that you all are not going to get what you think you are going to get, because of the deficiencies of the system, and I want to take you through that.

I might start with a couple of simple examples. We visited a mine sweeper. And a mine sweeper is, obviously, important. And there is a young sailor who is beaming. I go up to him and say, "what are you beaming about?" He said, "we just upgraded our computer." They upgraded from Windows 95 to Windows XP, which was delivered in 2001. His job, by the way, was to watch for mines 8 hours a day on the screen of his Windows XP computer. No one I knew, and no one I could find all up the chain of command could fix this obvious violation of Department policy around adopting Windows 10.

We have visited more than 100 sites, and one of the sites we visited we had 20 officers of various kinds, all very committed to innovation, and we had a presentation on innovation occurring at the base. A programmer gets up and shows us rapid development methodology, quotes from my book, talks about how it is all done right. Sounds great. We discover that there are only two people on the base that are doing this. Of course, there are 20 officers in charge of these two people. But I guess the even worse news is one of them is being reassigned to a different base and will not be able to do any more programming, and they cannot figure out a way to swap the billets so this person can stay in their base.

We are at a secret briefing with the National Security Agency on an opponent in the crypto-world by a very, very talented young crypto-expert who says that he is being transferred to a different base and will not be able to work on crypto anymore. This is the state of the talent of our young people and, frankly, why many of them are leaving for the private sector. They want to serve.

One of our new-generation airplanes had a potential software problem. We were asked to look at that. We went to visit. We discovered that it has a first-generation CPU [central processing unit], which was the processor that is in the airplane, that had been deployed and was out of date when it was deployed; but they are excited about a new version of this same CPU coming out in approximately 2024, which will be out of date when it is delivered. When questioned hard by our team, the rules were so constraining, the engineers did not have a choice. This is madness, in my view. I can give you example after example of this in the details.

So my conclusion, or our conclusion, is that innovation definitely exists, but there is no real mechanism and no incentive for the way the current structure is sort of adopted. And, in fact, if I can make a strong statement, the DOD [Department of Defense] violates pretty much every rule in modern product development. The spec is developed and is finalized before production starts. The way you really do it is you start iteratively and you learn from your mistakes and so forth. That is called agile development. It is essentially impossible to do, because of the way the rules are set.

There are no permanent software people. Software, when done right, is essentially continuous. And the way the software is done is the same way as hardware is procured. You write a spec and

then you wait for the software to show up, you make sure it meets all the specs and then the contractor goes away and you are done, which precisely delivers what you do not want now.

If you were in 2001, and you had been asked to write a spec for the equivalent of a smartphone in 2018, none of the technologies that are in the smartphone that you have today were effectively available in one form or another at the time. And yet, that is how we do almost all of our procurement, if you go back to the way the cycles work. It is crazy.

Much better to do it more iteratively. If you cannot do it every week, do it every month; if you cannot do it every month, do it every year. But once a decade means that the new hardware will mean that the new software all has to be rewritten, and, again, that is what drives the craziness.

Once certified, a weapon system cannot be changed. We were in a control center which had a secret classification, and they were using a protocol that I recognized as a computer scientist. And I said, "well, would it not be obvious to use this protocol, have a computer and have a military programmer take that protocol and then expose an answer that was useful for the air fighter?" And the answer came back, "that is illegal." And I said, "we are inside of a secret facility. You have a programmer who is a military programmer, and they are not allowed to connect a computer into your network?" And they said, "absolutely, because the whole thing was certified as unchanging." Again, a complete lack of understanding of how iteration and improvement would occur.

The model that the military uses where they outsource everything to large contractors has served us maybe well for these large weapons programs, but does not work at all for the kinds of stuff I am talking about. You need a completely different model. The networking computer resources are sort of out of the dark ages, like out of the 1970s. People wait for hours to log in, and then networks are slow. It is a complete violation of the concept of abundant computing resources, which allow people to build flexible systems.

The computer scientists, which we cannot find very many of, are not a separate track. Imagine if the way you did doctors and nurses in the military was you would have them become a doctor or a nurse for 6 months and then transfer them back out. It is a separate profession. It is obvious to me that computer science and, in particular, programming should be a separate discipline with its appropriate training and hierarchy and so forth.

There are many examples of systems where there are two systems that should have been interconnected, but vendor A built it this way and vendor B built it this way. And so we have soldiers, literally enlisted professionals that we, in our country, have, you know, asked to join the military, sitting there and it is called swivel typing. They look at it and then they read the number and then they type it over here. And then they read the number here and they type it over here, right.

Now, this is the easiest of all computer programming problems. And, again, a small programming team can do that in a weekend, and yet the system is not able to do that for the military. Enormous efficiencies out of such simple things.

Since every decision is protested, there is a risk strategy where not much risk is taken, because whenever the military actually makes a decision, they know that they will spend another year or two in some kind of contest. And it just goes on and on.

And I think this group feels strongly that this is not okay, but let us say you thought this was like, okay, things are fine, the country is doing well, it is important to note how at least one potential future adversary, China, is investing extremely heavily and rapidly in artificial intelligence, and has announced publicly that the goal by 2030 is to actually be the leading force in the world. So, again, there are competitive countries and competitive challenges that we need to address.

Now, we can talk about what to do. We have a long list. Our team produced a list of approximately 14 recommendations, which the leadership in the DOD has generally indicated they strongly agree with. And these are recommendations that are consistent with the things that I have talked to you about. Things like the COCOMs, the combatant commanders, should have 100 engineers to go fix things, that software should be a separate process, that there should be a program around psychological safety where the people are encouraged to take risks without losing their jobs. In fact, maybe people could be promoted because they took risks as opposed to promoted because they did not take risks, which is part of the culture. Trying to organize around big data, collecting data. If you are going to work in artificial intelligence, to do anything, you need the data to train against. Construction and setting up of an AI [artificial intelligence] center.

My personal view is that the R&E [Research and Engineering] and AT&L [Acquisition, Technology and Logistics] split that you all did a couple of years ago was very sharp, which brought Dr. Griffin in and his team, which is excellent. And I can also tell you that Secretary Mattis and Deputy Secretary Shanahan understand this very well and they are very, very committed to addressing these issues.

So I think we have strong leadership on the military side. I know that you all are very concerned about this. So I think these are problems that can be addressed.

Thank you very much.

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

The CHAIRMAN. Just very briefly, Dr. Griffin, do you largely agree with Dr. Schmidt's diagnosis?

Secretary GRIFFIN. It would be very difficult for me to agree more strongly with him. The way that we, broadly speaking, decide what we want to buy in the Department of Defense before committing to buying it has been, I think, broken for some years, which is, as Dr. Schmidt just said, why you created the position that you did.

I made a couple of notes here. Eric's comments about iterative development of software, I could not agree more. I used to be a software developer. Software is never done. But I would offer the following: Hardware development is done that same way. You build a little, try a little, test a little, find where it breaks, fix it, move on. When you have it working about like you like it, then it is time to write the requirements.

In the Department, we have a fixed process where we write requirements and then develop capabilities. The way real engineers do it is you prototype hardware, develop capabilities, and then, based on those capabilities, now you write the requirements for the production system that you really want.

So iteration in the hardware world is as important as it is in the software world. Let me stop there. We are in very high degree of alignment.

The CHAIRMAN. Okay. Did you have something you wanted to add, Dr. Schmidt?

Dr. SCHMIDT. I just wanted to add to Dr. Griffin's comment. So this requirements-driven process makes sense if you sort of hear it. It says, "Hey, let us write down what we want. The Government will procure that. We will know what the budget is, and we will get what we want."

The problem is that it produces outcomes that are not learning outcomes. There is no new feedback system. And the cycles in development in the general procurement have been increasing up to, say, 10, 12, 15 years, which ultimately causes us to miss the mark in the first place.

Secretary GRIFFIN. But by the time you have the hardware, you no longer want it, because it is out of date.

The CHAIRMAN. Let me just ask you each to address one other issue. It has been suggested to me that to have a, not only a culture, but an ecosystem that fosters innovation, an essential element is small to midsize businesses that are willing to disrupt things. And the suggestion that has been made to me is we make it too hard for these small, disruptive businesses to ever get into the DOD system. There is this program called SBIR [Small Business Innovation Research], whatever that stands for, which spends a lot of money, gets things started, but very little of it ever gets picked up in a program of record that goes on.

So I would appreciate each of you commenting on whether, in the Department of Defense, we need to have these small disruptive businesses and how well we are doing at getting them and bringing them into the system.

Secretary GRIFFIN. I certainly agree that most of the disruption that occurs in our technology ecosystem comes from small and medium-size businesses of—you know, we see the ones that succeed, we do not see the many that fail. And then, ultimately, they may very well get bought if they are successful by larger contractors.

I am not one to say that we do not need our large contractor industrial base. That is how we produce things at scale, but they are not largely the innovators that you seek. So I agree with your point there, sir.

Part of the difficulty—and I further agree that we are in the Department, and in the government writ large, we are not user-friendly for small and medium-size firms, which quite often lack accounting systems that are compatible with DCAA, sorry, Defense Contracting Audit Agency and Defense Contracting Management Agency. It requires a lot of corporate overhead—and this time last year, I was running such a company. It requires a lot of corporate overhead to deal with what we do in government.

Well, why do we do those things in government? We do them so that we in the executive branch can demonstrate that we can account for every penny. We go to so much trouble making sure that no misspending of money is possible that we actually create a larger mistake; we freeze out the innovators who maybe their accounting systems are not up to snuff, but their innovations are, and we leave those behind in an effort to make sure our systems are perfect.

If we could find a way to do more dealing on a commercial transaction basis, where, as a commercial entity, you know, your accounting system is your problem. I am buying a quantity of things from you and my interest is to make sure that you deliver those things on time. If we had more focus on outcomes and less focus on process, I think we in the Department could do better.

Dr. SCHMIDT. The Department of Defense has created two interesting groups. One is called DIUx [Defense Innovation Unit Experimental], and another one is called SCO, or Special Capabilities Office, both of which are central to solving this problem because they focus on the small disruptive businesses and try to use their tech to augment the larger systems.

There are groups. An example would be SOFWERX, S–O–F–W–E–R–X, and AFWERX, A–F–W–E–R–X, which are attempts to do that for the special operations forces as well as the Air Force. And the other services are now looking at this to address the question that you asked precisely.

So we are very clear, most innovation is going to come from these small innovative companies, by definition, because that is how they differentiate themselves. All of them complain that the cost of compliance to the rules of procurement is overwhelmingly difficult. They do not have the money, they do not have the people and so forth, whereas the larger companies do.

The CHAIRMAN. Have you had a chance, Dr. Schmidt, in your reviews to look at this SBIR program and how successful it is in getting small businesses into DOD mainstream?

Dr. SCHMIDT. I am aware of it. We have not done a deep dive on SBIR. Everything that the DOD can do to encourage more choices in terms of innovation is a good thing, whether it is individual contracting.

It is possible, for example, to hire small teams of software people who you cannot hire through the normal military process through special consulting arrangements. All of that should be tried.

And I want to emphasize what Dr. Griffin said about this need to track every dollar. I will give you an example. I am sitting with a very senior four-star general and I said, in a very nice, polite way, "you are a very powerful guy, why can you not get a team of 50 people in your huge budget to do the things you are complaining to me about?" And he said, "I did and they were taken away from me." And I said, "you have got to be kidding."

So there is something in the system that is a scavenging function that is taking these small groups that are interesting and innovative and under the direct control of our most senior military leaders, and taking them away from them. That is not smart.

The CHAIRMAN. Okay. A lot to go through, but Mrs. Davis.

Mrs. DAVIS. Thank you, Mr. Chairman.

And I think it is discouraging when we hear also that, in fact, you were able to find two generals, I believe, who really got it, and yet we are not able to make that happen, I think, in other ways.

So could you talk a little bit about, and, Dr. Schmidt, with your experience in the private sector obviously, there are a lot of ways in which we often have exchanges, bring people into the military, bring military into the private sector. Are we using every advantage that we have to do that? Have you seen ways in which we can do a far better job building that human capital so there is a real understanding of the role that one another plays? Because I think sometimes, you know, folks in the military may think, well, you know, they do not have to worry about the problems we have to worry about. And the same is true. How can we do that better?

And I also would wonder how can we do that better when it comes to developing that human capital at a much—prior to people getting into the service, for that matter, that we can try to bring some of that thinking to bear?

Dr. SCHMIDT. For this part of the military, I like to think of it as a very, very large corporation, with all the problems of a very large corporation, how do you hire people, how do you promote people and so forth.

The Department of Defense has something called the Defense Digital Service, which is a good example, where patriotic men and women will take a year or two off of their current jobs. They get permission to do so, obviously. And they come in and they fix problems. The problem with the Defense Digital Service, which is very, very successful, is it is very small, 20, 30, 40 people. We need 100, 200, 300. And given the way the government, in general, does software in particular, these kinds of programs are effective and I would encourage their expansion.

Corporations are not going to willy-nilly hand over their top talent, but there is enough motion in the system where, again, patriotic people are willing to take a leave from work. And you can imagine programs with the private sector where they will even keep their salary as a patriotic act in order to do this as long as it is time limited.

You emphasize in your opening comment the importance of STEM education. It is clear to me that the most important thing we can do to address the kinds of things I am talking about is more emphasis on STEM education of all kinds, at the community college level, college level, et cetera.

Mrs. DAVIS. Mr. Griffin, I think these are all things that we think are good to do, and some of them, of course, are being done. We need to scale that more. But do you see—and I know you are in this position somewhat new under this rubric. Does it actually transfer when people have had those experiences?

Are there things, just the requirements-based processes in the military, does that get in the way of people taking those good ideas and being able to deal with it, or will more people who understand this, in the end, be the difference between how we move forward in the future?

Secretary GRIFFIN. Well, there are a lot of——

Mrs. DAVIS. What would you do?

Secretary GRIFFIN. A lot of questions going on.

Mrs. DAVIS. Microphone.

Secretary GRIFFIN. There are a lot of important questions contained in that one question you asked. That is really quite broad.

First of all, the individuals who come in for these experiences and then go on to other avenues of life, they do retain those. We get valuable transfer both ways. As Eric said earlier, we have got fantastic people in the government and laboratory networks, in my experience, as good as those who can be found in commercial industry. It is, as he said, the system in which they reside.

Eric gave an example of a four-star who wanted to do something and the resources were taken away. Just a couple of weeks ago, I was having a conversation with another four-star, and we were commiserating on the swarming drone threat. And he said to me in almost a rhetorical conversation, "Why can I not just have some money and buy some drones of my own and put my guys on the problem of figuring out how to develop a counterattack and let them try stuff out, break some drones, and find out an approach that works?"

And I said—I will not offer his name. I said, "General, I could not agree with you more, but, in fact, I am an Under Secretary and you are a four-star and neither one of us has the power to route money to you to allow your people to do what you just said." It is the system in which we are trapped.

Now, in private industry—I once ran a GPS [Global Positioning System] company. If it had not been successful, I probably would not be here today. If I had to go through the kinds of permission loops to upgrade my receiver circuitry that we have to go through in the Department to catalyze and advance, I would not be here today. I would have been long out of business.

It is the system in which our innovators are trapped. It is not the quality of the innovators or the innovations.

Mrs. DAVIS. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Rogers.

Mr. ROGERS. Thank you, Mr. Chairman.

Thank you all for being here. Dr. Griffin, as you know, I have a very high opinion of you for a long time, and I am very proud that you are in this position. I know it is going to be a credit to our country.

This NDAA that we just completed gave you some pretty broad and sweeping powers, and I know you have only been in it for 2 months now, but can you tell me how it is working?

Secretary GRIFFIN. Well, sir, in fact, I have been in it 2 months today, 8 weeks today. And thank you for your kind comments.

Actually, I have to say the broad and sweeping powers that the NDAA 2017 allocated to us are more broad and sweeping powers to offer advice. USD(R&E) [Under Secretary of Defense for Research and Engineering] does not really have much in the way of specific directive authority to control what is or is not done. So it is more the power to persuade. I hope I am an effective persuader.

Mr. ROGERS. I hope you are effective too.

Conventional prompt strike hypersonic development needs to be accelerated. Can you tell me what your thoughts—and coordinated better. Can you tell me what your thoughts are about that?

Secretary GRIFFIN. You have hit my number one hot button, sir, as I think I may have mentioned that in my confirmation testimony a couple months back.

I will say that, in my opinion today, the most significant advance by our adversaries has been the Chinese development of what is now today a pretty mature system for conventional prompt strike at multi-thousand kilometer ranges.

We will, with today's defensive systems, not see these things coming, and they have an all-azimuth capability. They can come from any direction. We will not see them coming beyond several hundred kilometers of range; and once inside that range bucket, we have very little time left to respond.

It is a tactical system that has strategic import for our Nation because it, if employed, could have the effect of limiting our ability to project power in the maritime domain. And as you well know, sir, you are the subcommittee chairman for Strategic Forces, I think you know how important our ability to sustain carrier battle groups and other maritime domain assets is to projection of U.S. strategic will throughout the world. And this capability is under threat today. We must respond with our own offensive capability, and we must, with all deliberate speed, develop defensive capability.

Mr. ROGERS. Excellent. And I know you will.

Finally, directed energy is something I feel very strongly about us maturing as quickly as possible. You know, it has been 5 years away forever. But, as you know, this technology is pretty mature, but it needs some more focus and attention.

And one of the things that I am concerned about right now is that it is being developed in three different areas, three different programs, instead of being focused generally in Missile Defense Agency. Can you tell me what your thoughts are about why that development has been spread across three different programs?

Secretary GRIFFIN. I am not sufficiently knowledgeable of the history to know how we got where we are. And in business school, they teach us that some costs are irrelevant anyway.

So my mission is to go forward and unify our directed energy development across the Department. That is what I want to do, because right behind the hypersonic threat, I am concerned that we are not leveraging our technical advantage in directed energy weapons. Within a few years, I want this Nation to have a, I will say, 100-kilowatt-class laser that can be deployed on a Stryker. I want us to have a several-hundred-kilowatt directed energy capability that I can put on an Air Force tanker so that it can defend itself. By the latter part of the next decade, I want to have a megawatt-class device that can go in space and protect us against enemy strategic missiles.

These things are within our grasp if we focus our efforts. They absolutely are within our grasp.

Mr. ROGERS. Well, I want what you just described, so get after it.

Secretary GRIFFIN. Please help me get it, sir.

Mr. ROGERS. I am with you. Thank you very much.

I yield back, Mr. Chairman.

The CHAIRMAN. Mr. Langevin.

Mr. LANGEVIN. Thank you, Mr. Chairman, and good morning to our witnesses. I want to thank you for being here with the testimony. I think this is an important discussion that we are having.

I have the privilege of serving as the ranking member of the Emerging Threats and Capabilities Subcommittee, so we have primary jurisdiction over all of the Department's cutting R&D [research and development] programs, including those at DARPA and ONR [Office of Naval Research]. And so the more we can do to cut out the red tape and accelerate these programs, I think the better off our Nation will be.

Dr. Schmidt, let me start with you. Of the recommendations made to increase innovation in the Department, which is the most imperative, and has the recommendation been adopted—I am sorry, been adopted and actually seeing it come to fruition?

Dr. SCHMIDT. Thank you very much. Many of the recommendations are in the internal reviews of the DOD. And the military has generally said they are going to implement as many of them as they can. The one that seems to have gotten the greatest traction right now is the proposal around an AI center. And we are specifically proposing that the nature of AI is a long-term technology that will be useful for defensive and perhaps offensive purposes as well. And so the creation of that is under review right now and I suspect will occur.

We are also recommending, for example, that that be done in conjunction with a university of some kind or a couple of universities. So trying to make sure it is world class.

Mr. LANGEVIN. How do you feel innovation can be scaled?

Dr. SCHMIDT. Well, this is what I have done my whole career. And you can systematize innovation by doing essentially reviews, quick decision cycles, and that. Remember that the biggest mistake is not starting something that does not work, it is continuing something that does not work. And so you want to fast fail. And, again, Dr. Griffin has emphasized this in his notes as well.

So I would suggest that the government spend a fair amount of time doing reviews that are pretty rough. It is very difficult in the DOD to cancel anything, and yet the budgets are always fully allocated. So if you want to have room for innovation, you are going to have to stop doing a few things. And I am not talking about the big systems. I am talking about lots of other things that they are also doing.

Mr. LANGEVIN. Thank you. It is a good segue into my next question.

Dr. Griffin, so any future conflict will undoubtedly include advanced technologies, like directed energy or hypersonics or railgun, and we recently had a conversation about these topics in my office and I thank you for the courtesy call. You came by.

So it is not just because of us pursuing these capabilities, as you and I spoke about, our adversaries are clearly investing heavily in these areas as well.

So do we need to be more aggressive in our pursuit of these capabilities? And how do you believe we can better promote a culture more accepting of failure in this pursuit within the Department of Defense?

Secretary GRIFFIN. Thank you, sir. The first thing that pops into my mind when you say how can we institute a culture that is more accepting of failure, from the heart, what I think we need to understand is that it is not failure to learn that something we tried did not work on the way to our major goal.

If our goal—Chairman Rogers was asking me about directed energy weapons and I know you are interested in those as well. If my goal a decade from now is to give the United States dominance in missile defense in the world by means of having a megawatt-class laser, that is my goal. Failure is failure to reach that goal. It is not a failure to try out different approaches to reaching that goal and have them break along the way as long as I do not lose sight of my strategic goal that I am going to have a megawatt-class laser in 10 years.

And breaking hardware along the way to that goal is not a failure. In fact, breaking hardware along the way to that end goal is often—and I am tempted to say always, but I am sure there are exceptions—breaking hardware along the way is often the quickest way to get to where you want to be.

And so there is a cultural mindset here that in the course of trying to prevent small failures along the way to the grand goal, we miss the grand goal.

Mr. LANGEVIN. Thank you.

Secretary GRIFFIN. Thank you, sir.

Mr. LANGEVIN. As I mentioned, we in Congress, of course, have to work with—we want to be supportive of these innovative efforts. And as long as we are taking these journeys together and we have an open line of communication, when failure occurs, again, this is something that we can take these leaps together and understand where we want to get to and be supportive of your efforts.

Thank you, and I yield back.

The CHAIRMAN. Mr. Wittman.

Mr. WITTMAN. Thank you, Mr. Chairman.

Dr. Griffin and Dr. Schmidt, thanks so much for joining us today. Dr. Griffin, you have spoken repeatedly about the role hypersonics will play in this era of great power competition between the United States, Russia, and China. And you also stated specifically that they are your highest priority.

You went on to state, in your words, "I am sorry for everybody out there who champions some other high priority, some technical thing; it is not that I disagree with those. But there has to be a first, and hypersonics is my first."

Other than funding, how do you transitionally get that redirection towards hypersonics, get us to the point where we are not only catching up, but surpassing our adversaries? So I wanted to get your perspective on that.

Secretary GRIFFIN. Thank you, sir. Let me add that I have a good-sized list of priorities that come to us out of the National Defense Strategy [NDS] that was released in January. I am not often a fan of government assessments, but this one was really well done. And that gives me my—it gives me my marching orders, if you will. And, of course, the NDS did call out hypersonics and, as you correctly point out, I have emphasized that.

To be honest with you, this Nation's earlier research work in hypersonic systems development was basically what our adversaries have used to field their own systems. It is time for us to renew our emphasis on and funding of these areas in a coordinated way across the Department to develop systems which can be based on land for conventional prompt strike, can be based at sea, and later on, can be based on aircraft.

We know how to do these things. This is a country that produced an atom bomb under the stress of wartime in 3 years from the day we decided to do it. This is a country that can do anything we need to do that physics allows. We just need to get on with it.

Mr. WITTMAN. Very good. Thank you.

Dr. Schmidt, let me pick your brain. In your role, you look at a lot of different opportunities. One of the opportunities that I think has evaded us to this point is how do we take needs within the Department of Defense and combine that with the innovation and creation that exists within the outside community and look at the conduit of venture capitalists who look to invest in those emerging technologies who normally have not been connected with DOD? How do we make that connection? How do we get those companies that have been innovated on the commercial side to say, "Hey, there is an application of what we do and the attraction of capital to that to accelerate the development of those technologies?" Give me your perspective about what we can do to better make that happen?

Dr. SCHMIDT. So, unlike Silicon Valley companies, the DOD is extremely top-down. And so the NDS that Dr. Griffin mentioned is crucial here. It has roughly 10 big buckets, and the military is now trying to organize its activities into these buckets. And that is a crucial signal to the venture capital industry to say, work in this area.

Then the next thing to tie in is the notion that there is a new approach to a problem, a faster this, a smarter that, and so forth, often software. And that is, I think, where the current lack of link is, that the people who are running those parts of the DOD are not technologists, they are generalists, and they do not have someone to say, "Hey, you know, there is a new way to solve this problem and all you have to do is take a look at over here."

I have championed having various internal bake-offs and so forth. Dr. Griffin is central to this role and understands this role very well, as one of the people to bring this into the DOD. He will not be successful without the rest of the DOD being in alignment with these 10 broad areas and calling him and working with him, looking for these things.

Mr. WITTMAN. Got you. Very good.

Dr. Griffin and Dr. Schmidt, one final question. In this era of great power competition, we are not going to be where we were in the past, and that is to out-resource our opponents, whether it was what we did in World War II, or we did during the Cold War. Where we will prevail today is we must be able to do more per our unit of currency than our adversaries do per their unit of currency.

Give me your perspective on how do we start down the path to be able to do that? And, Dr. Griffin, you spoke a little bit about this, about us being the creators and innovators, but how do we ac-

celerate that to truly, in this era of great power competition, prevail?

Secretary GRIFFIN. Well, sir, as I tried to say earlier, we are not out of innovators, we are not out of innovations, we are out of time. And it is about pace. We must match the pace that our adversaries are demonstrating today.

So a few weeks ago, I was fortunate to have some private time with the chairman, and he asked me, essentially, the question that you asked. And I often pop off with the wrong remark, but in this case, I said, "Sir, we can either retain our national preeminence, or we can maintain our processes, but you cannot have both." Okay? We have got to thin out our process structure like weeds in your favorite garden, and nothing else actually matters. If we do not thin that out, nothing else is going to matter.

Mr. WITTMAN. Thank you, Mr. Chairman. I yield back.

The CHAIRMAN. Mr. Larsen.

Mr. LARSEN. Thank you, Mr. Chairman.

I want to explore that last question over here that Mr. Wittman asked a little bit more, because when we developed the atomic bomb, we sort of controlled that process. When we developed the space program, except for the Soviets—that is, the government controlled it. Developed the space program, the government controlled it. To catch up or to lead on AI, on quantum computing and machine learning, we don't control that. It has largely already been driven by the private sector.

And so the fundamental question I have, is there a moneyball question here? That is, are we going to only be hitting singles and doubles, like the DDS [Defense Digital Service] or the SCO or DIUx, or do we get into an issue where or get to a place where we are hitting home runs? We are actually able to do a government investment into quantum computing, into AI, that is big enough to set the foundation? Otherwise, we are relying on the private sector to do that, and the private sector may not want that big investment from the government to help them leapfrog the foundational technologies.

Secretary GRIFFIN. Well, sir, the private sector will, and with the grace of God in this country, do what will do well for them. And they should, because that is——

Mr. LARSEN. I agree.

Secretary GRIFFIN. And that is the strength of our industrial base. So the question is, how we in the Department can take on some of the advances that they are making and put our money in on the tasks that we want done for us using these new technologies.

So Dr. Schmidt, a few minutes ago, mentioned that one of the advantages of having, say, roughly 10 buckets of priority development, is that when venture capitalists can see the Department putting its money there, well, they will go and do likewise.

So I think emphasizing AI, through an AI center and other things, we in the Department are not trying to build up AI to solve commercial problems. We are trying to build up AI to solve defense problems. And I believe that industry specialists in that area will be attracted to our challenges.

Mr. LARSEN. So what is the return on investment of that, Dr. Schmidt, in the private sector, for the private sector?

Dr. SCHMIDT. Well, for the private sector——

Mr. LARSEN. You need your microphone on, please.

Dr. SCHMIDT. I apologize. For the private sector, the investments that are being made in machine learning and AI and big data are fundamental to the future of those industries. So I can assure you that, broadly speaking——

Mr. LARSEN. The ROI [return on investment] for them is very clear. I am talking about the ROI for them to have the DOD either to invest in it, or for the DOD to be able to utilize that technology, which may or may not be proprietary.

Dr. SCHMIDT. Well, historically, the DOD investment kick-started many of the industries which I have been part of. You go back to the original work that DARPA did. And DARPA today is, for example, funding key investments in the areas that you are describing. So we benefit from fundamental research that the military funds.

If it is a question of a military program, then it has to be looked at on a cost-benefit basis by that company. And, again, to the degree that the government can make it easier for that company to work with the government, that is a net benefit. But my answer to all of this is more, right?

So an AI center, which we are proposing as part of my group, that is run by the DOD, benefits the private sector as well, because it puts more money into working on hard problems.

Mr. LARSEN. So my concern is less about any one military program. There are 1 million of them, and there will be 1 million more. It is about the foundational technology investment, where, as a government, we do not control that like we did when we developed the atomic bomb or developed the space program. We were the first entry, the first in the market, if you will, but we are not the first in the market on AI, on quantum computing, the machine learning, and go down all this list that we are competing with with China and Russia.

So I am trying to get past, or get through, talking about, you know, the DDS or the SCO, where we are borrowing people and we are borrowing technologies across services to utilize something new, and talking more about the foundational technologies that we have to invest in to be where you want to be, Dr. Griffin, in 5 years on directed energy and 10 years on directed energy and so on. Where do we want to be in 10 years on quantum computing in use by the DOD? Well, we do not seem to control that as much, because of a great innovative system that we have.

And that is just a fundamental challenge I think that I would like to hear an answer to, a better answer to. My time is up. I apologize. Thanks.

The CHAIRMAN. But if you want to make a comment.

Dr. SCHMIDT. Well, again, I think that the relationship between the tech industry and research funding that has come over history from the government has been profound. I, as a graduate student, was on a DARPA grant and on a National Science Foundation grant.

So the more basic research that you all, in aggregate, can fund across the sciences and so forth, it really does benefit the military

mission. It really does benefit the defense of our Nation. It may be indirect, but the fact of the matter is that every conversation, pretty much every conversation we have had so far this morning started off with some form of government or National Science Foundation funding for the basic research that created it.

The CHAIRMAN. Mr. Scott.

Mr. SCOTT. Thank you, Mr. Chairman.

Dr. Griffin, I, again, respectfully want to bring up what the chairman brought up earlier. We received the testimony at 9:20 this morning. That makes it difficult for us to do our job. And this seems to be becoming more commonplace from the DOD, that we do not get the testimony in a timely manner.

You gave the example of the drones and the swarm of drones and being an Under Secretary, and that a four-star general that you were with, that neither one of you had the authority to do what both of you thought needed to be done with regard to the procurement and potentially war games with drones.

My question gets back to, is that real or perceived that you do not have the authority? Show me the language that prohibits you from doing what you and the four-star want to do; and I think that you would find the committee willing to, in a bipartisan manner, remove that language from the law.

Secretary GRIFFIN. Sir, first of all, I again apologize for being late with the testimony and will endeavor to see that that does not happen again. The fault is mine, and I will remedy it.

With regard to there is no language in the law specifically prohibiting me from doing what you suggested in the example I cited. There is no language that specifically gives either myself or this particular four-star the permission to do it. And absent the documented permission to do it, it is presumed that you cannot do it. And this is a cultural issue within the executive branch of the government writ large——

Mr. SCOTT. Absolutely.

Secretary GRIFFIN [continuing]. Not just the DOD, sir.

Mr. SCOTT. I agree, it is cultural. And if we as a government are going to take the position that our DOD and the people that run the DOD, both on the civilian side and the uniformed personnel side, have to have the express written permission of Congress to do anything, then we need to be learning other languages, because at some point somebody is going to conquer us.

And my question then gets to, how do you break that culture? Because Congress does not prohibit you from doing what you and the general agree need to be done. It is a culture. It is a decision that is made inside the DOD to not do things that need to be done.

Secretary GRIFFIN. Well, yes, sir, but let me expand my answer just slightly more.

Unless I can find something in authorized and appropriated language and funding which fits the category of this particular—say, response to swarming drones, unless I can find money which is appropriated for that purpose and authorized for that purpose, I do not have a documentable, if you will, chain of permission going to the very top of the government that allows me to do these things.

And so, absent that clear succession path for the use of money, by definition, I am using it inappropriately. And——

Mr. SCOTT. I am almost out of time. If I could, though, I mean, the pistol example with the Army. The Army took 10 years to buy a new pistol. And, now, fortunately, they had a pistol that worked while they were taking the 10 years to do it. But when you ask the Army, "why did it take 10 years?" they cannot answer the question.

It is a bureaucracy that is built upon a bureaucracy, and there is a lot of blame that goes around. We all know what the problems are. We need to know how to eliminate those problems and remove those problems.

Dr. Schmidt, one of my concerns, as we work on these issues, is—and I know you are very tuned into the private sector and compensation in the private sector—whether or not it will be uniformed personnel or civilian personnel that are actually the best solution for us in the programming aspect of things.

But even in the civilian personnel, a GS–7's starting pay is $35,000 a year. That is for somebody with a college degree. How do we compete with those pay scales? And what are your thoughts on uniformed versus civilian personnel in the programming fields?

Dr. SCHMIDT. We are fortunate that a number of people are willing to work for very low wages out of patriotic duty to solve these problems. And they will do so until they feel that their ideas and innovative ideas are ignored by their bosses, and then they leave—and I have encountered many such people—to go to much higher-paying opportunities in the private sector.

If we want do this long term, we have to have softer budgets that can be sent through softer contractors, where the contractors are being paid market wages. And that is legally achievable; it is just not done as practice. And you all have already given permission for this to happen.

Mr. SCOTT. Thank you, gentlemen.

The CHAIRMAN. Mr. Carbajal.

Mr. CARBAJAL. Thank you, Mr. Chair.

Dr. Griffin and Dr. Schmidt, I have the honor of representing a number of universities in my district, including UC Santa Barbara and Cal Poly, San Luis Obispo. Both of these institutions participate in a number of research opportunities offered by the Department of Defense. The experience has not only been rewarding for DOD, as they enhance their technological edge, but also for the students, as these partnerships allow students to pursue advanced research and directly impact the security of our Nation.

I believe it is critical for DOD and Congress to expand these DOD-academia partnerships as part of DOD's efforts to foster and promote a culture of innovation.

Secretary Griffin and Dr. Schmidt, how important are these DOD-academia partnerships in enhancing innovation? Are there are any new initiatives within DOD to expand and create more partnerships such as DOD educational partnership agreements and university affiliated research centers?

Secretary GRIFFIN. To the last part of your question, sir, I do not at this point know if we have any new partnerships planned or what those plans might be. I will be happy to look into that.

With regard to history, however, I, myself, spent 11 years in DOD and NASA FFRDCs and UARCs. I am the strongest possible believer in the value of these laboratories and centers and such,

where the U.S. Government partners with a university to bring a technology development focus on a particular area.

So, for example, with NASA and JPL [Jet Propulsion Laboratory]—and, of course, the DOD has a lot of interest in JPL as well—we hire Caltech to run JPL for the benefit of the government and the taxpayers. It has been an extraordinarily productive thing to do. I could repeat that same story with regard to the Johns Hopkins Applied Physics Laboratory or Los Alamos or many others.

This is what got us where we are. And one of my goals is to make sure that those partnerships are strengthened and reaffirmed into the future.

Dr. SCHMIDT. One of the best ways to address some of the shortfalls in innovation is to work more with America's leading universities, which are top of class globally. And the more we can do that, the better.

I should highlight that UC Santa Barbara is a center of extraordinary progress on quantum computing, and some of the major breakthroughs in quantum computing appear to be coming through the research done there in the physics department.

Mr. CARBAJAL. Thank you both.

Mr. Chair, I yield back.

The CHAIRMAN. Ms. Stefanik.

Ms. STEFANIK. Thank you, Mr. Chairman.

In a full committee hearing last week, General Alexander, who, as you know, is the former commander of U.S. Cyber Command, stated, quote, "The leader in artificial intelligence and quantum will be the next world superpower."

I am deeply concerned that we must be able to keep pace with near-peer adversaries like China when it comes to their investment in AI. As you stated, Dr. Schmidt, in your opening statement, China has publicly stated their goal to be the global leader when it comes to AI by 2030. That is not very far away.

What specific steps do we need to take within the DOD, in addition to research and development, to ensure that we are able to keep pace and surpass near-peer adversaries?

And, Mr. Griffin, if you can specifically talk about what we are currently doing within DOD regarding AI.

Dr. SCHMIDT. As we discussed earlier for Dr. Griffin, hypersonics was his first of a number of firsts. For me, the AI questions are first among a number of firsts.

And, in order to do AI, you need to have data for training. And the DOD, broadly speaking, has a great deal of data which is not stored anywhere or stored in places which, you know, the programmers are no longer alive kind of thing. And getting all that data in a place that is usable and discoverable and useful for the mission at hand is crucial.

We have already highlighted the importance of having some form of AI center, again, from my perspective, preferable if it is done in conjunction with some universities, to take the work at the state of the art.

The third is that the majority of the contractors that are used by the DOD are not AI-capable at this moment, although they are all working on it. So, again, I would encourage the specification,

and the current process, which is essentially a requirements document, needs to actually state what problem they want to solve.

A typical example would be, you are worried about a swarming drone problem with autonomy, right? That is a good example of an AI problem. Where is the research? Where are the tools? Where are the drones? Where are the counter-drones? All of those kinds of questions need to be asked, but they need to be asked in the context that causes the data to be stored and the algorithms to be invented and funded.

Secretary GRIFFIN. The Defense Innovation Board has recommended and Dr. Schmidt has emphasized the need for an AI center. I believe, in his hearing recently, the Secretary affirmed that the DOD will establish an AI center.

So that, I believe, comes under my area, and we are looking, right now as we speak, about things like how do we structure it, who should lead it, where it should be, how we should structure our other departmental research to focus in through that. So these are ongoing questions that we are addressing this week.

Currently, I was briefed recently and told—I cannot verify the number, but I was told that we have 592 separate AI-related projects across the Department. We need to bring some focus to all of that, and I think that is what you are getting at, ma'am.

Ms. STEFANIK. To follow up, Dr. Schmidt, some of the technology companies we have talked with, and particularly those that are contributing in the areas of AI, have expressed a reluctance to work with DOD.

And I know you are not here today in your capacity with Google, but you are familiar with some of the news articles related to the workforce's questioning and concerns regarding DOD's Project Maven.

How do we overcome this skepticism? Because I think this private-sector workforce is critically important, to be able to leverage their innovations, when it comes to what DOD is doing in AI specifically.

Dr. SCHMIDT. So, because of my role in both organizations, I have been deliberately kept out of the particulars here, so I honestly cannot answer the Maven questions at all. I honestly do not know.

My sense of the industry—the answer to your question at the industry level—is that the industry is going to come to some set of agreement on AI, what are called, principles—what is appropriate use, what is not. And my guess is that there will be some kind of consensus among key industry players on that.

And then that process, which will take a little while, will probably then inform how Dr. Griffin and his teams, you know, leverage, work with, work against, what have you. I think it is a matter of speculation, but my guess is that is the path.

Ms. STEFANIK. Thank you.

My time is about to expire.

The CHAIRMAN. Mr. Panetta.

Mr. PANETTA. Thank you, Mr. Chairman.

Gentlemen, thank you for being here and, obviously, your preparation as well as your testimony.

Playing off Representative Carbajal's question, he talked about outside universities. What about internal universities, defense-re-

lated universities, Naval Postgraduate School for example? Are they contributing to this innovation so, instead of having a top-down, we are basically from the bottom up, from people within the Department of Defense?

Dr. SCHMIDT. So one of the goals for the Naval Postgraduate School by the Navy is, because of its location and storied history of training top leaders in the Navy, to have it serve as an innovation hub and, in particular, have business contacts with the venture community and so forth. That is an objective that they have, and we certainly support that.

In general, the educational systems within the military, as a broad statement, could be improved by working with and sharing abilities with the traditional public-sector universities, et cetera. In other words, a university that is sort of private and isolated does not serve the military well. A university or a training program or an open innovation program that is linked to the educational systems of America serves both sides.

Secretary GRIFFIN. I mean, I would agree. I am very familiar with the Postgraduate School and somewhat familiar with Air Force Institute of Technology, for example. And, while they are quite good at very specific things, the more that they can be linked with their academic cousins outside the Department, the more that they become—I do not mean this in any disparaging way—the more that they become just another university that happens to have ownership in the DOD, the better we are going to do.

Because I think there is just no argument that, taken in total, the American system of higher education is the world's best. And, yes, it has faults and it has problems and problems that we need to solve, but, taken globally, it is the best. And we ought to try to promulgate that as much as we can. We ought to try to use it as much as we can, support it as much as we can, and let it run free, because it has done well for us.

Dr. SCHMIDT. May I add something?

Mr. PANETTA. Please.

Dr. SCHMIDT. The challenge that we face in the government and the military is a much deeper training and education problem than it initially appears. Because many of the doctrinal approaches, right, are being torn asunder, right, they are literally being turned on top of each other, by changes in adversarial posture or technology. So an agile, innovative leadership team is a very different training program than the kind of leadership we are training today.

And so think about it—just simple things like there is something called the Acquisition University, where people learn how to do acquisition. Well, that all has to change based on what Mike has outlined here. There are thousands of people who go through these systems.

So it is a much deeper tautological question than it might initially appear. Your question is exactly right.

Mr. PANETTA. Thank you, gentlemen.

I yield back, Mr. Chairman.

The CHAIRMAN. Mr. Bacon.

Mr. BACON. Thank you, Mr. Chairman.

And thank you, Dr. Griffin and Dr. Schmidt, for being here and providing your testimony.

You have given some good updates on hypersonics, artificial intelligence, quantum computing. There are some other areas that also I think in the next 20, or 30, or 40 years we will see weapons technology migrate to. One of them is miniaturization of weapons.

Can you give us an update on how we are doing in that area? Are we seeing progress? For example, I think eventually we will see remote-piloted aircraft that will be very small that could be used for ISR [intelligence, surveillance, and reconnaissance] or for kinetic operations. But do you have any updates in the miniaturization efforts?

Secretary GRIFFIN. Well, I do not know that I have any specific updates, sir. There are a number of areas where, as you indicate, there is a driver to miniaturize. And when you have that technological driver, you will generally get results.

Today, for example—I started in missile defense when the best and first interceptor we could build weighed a ton. And I do not say that as an exaggeration. It literally weighed 1 ton. The missile defenses that we have at Fort Greely and Vandenberg today, ground-based defenses, the interceptors weigh a couple hundred kilograms.

Can we make them smaller and lighter? Yes. And we will, because our next advance will be the Multi-Object Kill Vehicle, where one bus can support several smaller interceptors. As you point out, unmanned aerial vehicles are following this path. Not everything needs to be Global Hawk, as wonderful as Global Hawk is.

When we are challenged to advance our technology because of adversarial postures, we will do that. What this hearing is as much about as anything else today is reforming our processes——

Mr. BACON. Right.

Secretary GRIFFIN [continuing]. To allow those innovations to come forward in a timely way. I think both Dr. Schmidt and I—that has been our central theme.

Mr. BACON. Dr. Schmidt, anything else to add?

Dr. SCHMIDT. No. I agree with Dr. Griffin.

Mr. BACON. Uh-huh.

Another area that I read about is robotic-type warfare or the use of robots more. And I have heard that Russia has put a lot more emphasis on that than we are. Do you have any other feedback on that area?

Secretary GRIFFIN. Sir, I am unable to address that question. I do not know the Russian posture in robotics, and I am really only cursorily familiar with our own.

Mr. BACON. Okay. Thank you.

Secretary GRIFFIN. I am sorry.

Mr. BACON. One last question. On the F–35 front, we have had a lot of experience with that, obviously. Again, some good progress now, but also we have had some tough times. What have we learned out of the F–35 that you can apply?

Secretary GRIFFIN. Well, F–35 comes under my counterpart, Ms. Lord, for acquisition and sustainment. I would broadly observe—so I will be very careful in my remarks, and they will be very top-level, because it is not my program.

But I would observe that a program which has been in work for over two decades and now performing well, but in work for over two decades, is, frankly, late to need. It almost automatically cannot be said to keep pace with the threat.

I think that it is well known, at least on the inside, that the software architecture is not one that would have been developed, say, by our leading IT [information technology] providers. It is not the kind of software architecture that a Google or an Apple or a Microsoft or a Cisco would have provided.

So there are a number of systemic issues there that I hope will be lessons learned for the next spin. And I think it would be better for me to stop there.

Mr. BACON. Hopefully we just keep learning with each program like this. That is what we do.

Dr. Schmidt, anything else to add?

Dr. SCHMIDT. I think that Dr. Griffin's comments reflect the fact that you think of the F–35 and these other programs as hardware programs, but they really are software programs with hardware attached.

And so, if you thought about it as a software project and had designed the software in such a way, the kind that I am describing, and as done in the industry, you would have a very different outcome today. And that is at the root of the design, procurement, and operational methodology for these large systems.

So think of it as, let us get the software right in the future, and then we will figure out what airplane to build around that or what airborne device to build around it. That is a much better approach going forward.

Mr. BACON. Okay. Thank you, gentlemen.

And, Mr. Chairman, I yield back.

The CHAIRMAN. Mr. Carbajal—I am sorry. Mr. Gallego. I have to go to the next one on the list.

Mr. GALLEGO. All of these Marines are the same, are they not? Thank you, Mr. Chair.

You know, we are actually very proud in Arizona to have a Cyber Warfare Range. And it is an incubator to train the future cyber warriors. And it is, you know, a great place. It is a nonprofit. By design, it is a nonprofit, not government-run. And that is something that I think has made it be fairly flexible in both creating its curriculum and also in terms of outputs.

But, you know, if it was a government program, it is my opinion and, I think, the opinion of many people that it would be a little slow in terms of its being able to change and adapt to environments, change the curriculum, be able to retain and attract students. And, you know, in this environment, we need the cyber warriors to come out as fast as possible, as strong as possible, as smart as possible, and as trained as possible.

What can we do to encourage that type of environment, especially, kind of, from top down in this stuffy world that we deal with when it comes to, you know, DOD policy versus what we need, you know, what I would say is a very aggressive cyber warrior and cyber warfare policy?

And we will start with you, Dr. Schmidt.

Dr. SCHMIDT. So the great thing about cyber warriors is that, relative to the other things we are talking about in the military, they are very inexpensive. The salaries are relatively low. You do not need that many. They are brilliant people.

And I am beside myself over why we do not have a surplus of such people. We have such a shortage. They are the cheapest and highest, most effective part of our defensive systems. And I think it is because we do not have a name for them. As Mike said, he does not have a line item for doing what you just described.

So you could imagine that, as a part of a future NDAA, you could say, we would like to have a thousand of this kind of person, under the command of the Secretary, doing useful things. Right?

And I think that the only way you will get that is by doing some form of numeric quota around the people. In the same sense that we argue over the number of airplanes and ships and so forth, why do we not simply say, we need this many people, and then the system will produce the top people into that.

Mr. GALLEGO. And, Dr. Schmidt—before we get to you, Mr. Griffin—I am sorry to put you on the spot, but just out of curiosity, since you brought it up, if you had to even pinpoint a number, just a guess out of the blue—or, do not guess, but your best educated guess at least—what is the amount of cyber warriors we would need in this country?

Dr. SCHMIDT. Well, the general answer in my industry——

Mr. GALLEGO. Not enough.

Mr. SCHMIDT [continuing]. Is a thousand.

Mr. GALLEGO. A thousand. Okay. Wow.

Dr. SCHMIDT. And in the military it is probably a small number of multiples of that.

Mr. GALLEGO. Wow. That is amazing. Okay.

Mr. Griffin.

Secretary GRIFFIN. Well, I would just offer a couple of comments in addition to those that Eric provided.

Cyber defense is, of course, critically important to the Department, but I am going to go out on a limb and say that it is even more important to those who guard our economic systems of banking and financial industry and all of that. And so the Department is looking toward bringing in—we have a new CIO [Chief Information Officer] who will be coming in from the financial industry. I think we need to do everything we can to tap into people who are, if you will, playing for their own money in this arena. And we are doing that.

Eric mentioned, you know, my comment that, well, unless I have an appropriated and authorized line item, I cannot spend money on something. If you want to emphasize cybersecurity, both offensive and defensive—and it is one of my priorities—since we all agree that we do not really know very much about what we are doing in this area, when you give us the authorization to hire these thousand people, you cannot be too specific about what I have to do with them, because I do not know right now. You have to have a little bit of trust in us to use the money——

Mr. GALLEGO. Right.

Secretary GRIFFIN [continuing]. As the need evolves. Because we hope to learn more about cyber defense and offense to produce an

adequate cyber warfare capability, but I cannot sit here and tell you right now that I or anyone else we have knows exactly what that should look like.

Mr. GALLEGO. So the cultural change, then, both has to be on the DOD side as well as, what you are basically asking, on the political side, in terms of how we appropriate money and legislate money then. At least give the flexibility to be able to do that and basically allow people to fail, like they normally do in the private sector.

Dr. SCHMIDT. Let me help Mike out.

Mr. GALLEGO. And do that in 10 seconds. Go.

Dr. SCHMIDT. He described precisely the problem. He wants to do something; he cannot find a budget item which allow him to find the money to legally spend it. And the problem is we have the Armed Services Committee, we have the appropriators, and then we have the internal budgeting processes within the DOD, all of whom organize to make sure that there is no wasted individual.

Well, we cannot precisely define what these people are going to do, but we know we need them. And they are not expensive compared to the other things that we should be focusing on.

So there are certainly things that you all should be focused on that are the big-ticket items, but I would strongly encourage you to have a small number of buckets which somebody like yourself is taking a look at, where you say, hey, let them try it, let them experiment. And whether it is hiring people or money that goes to universities, these are honorable people that are trying to do the right thing.

Mr. GALLEGO. Thank you, Mr. Chair. I yield back.

The CHAIRMAN. Just so I can clarify, because—so, are you talking about X number of people in your organization, Dr. Griffin, who you could use as a task force to go do this, that, or the other thing? Because we have this whole Cyber Command that does a whole variety of things, and we have been pouring money and people into that.

Secretary GRIFFIN. Generally speaking, sir, when I talk about deploying people to a problem, I am not talking about necessarily DOD civilians or military officers. There may very well be some of those or even many of those.

But I am really talking about the necessity to engage our laboratories, to engage our universities, to the flexibility to stand up a cell in the Department if we feel that we need to, or the flexibility to put work where we think it can best be done.

But, no, I am not talking about going out and hiring thousands of civil servants. That is not my primary goal.

The CHAIRMAN. And I am just sitting here trying to think, okay, how do we write something that gives this sort of flexibility as a trial? Because it will be a challenge for the appropriators to agree to the broad flexibility. I am trying to narrow it down, say, a pilot or something.

Dr. SCHMIDT. So, again, with sympathy to the problem you are trying to solve, I can imagine you saying, here is a pot of money, which is not a large amount relative to the amount that you normally deal with, and that you reserve the right to review how it has been spent every 6 months or so and that you are open to how it be spent. Right? In other words, we are going to trust the other

side, but we are going to inspect. You go back to "trust, but verify." I think that is a completely appropriate view that you should take.

The problem is that you do that, and then, for the next 6 months, many other people are saying yes and no, rather than letting people come up with some new ideas, experiment, come up with some new ideas. And then, at the end of day, the next 6 months, you would say, we got some good things and we made some mistakes. And, again, Mike or his equivalent will come back and say, we want to be honest with you, this worked, this did not, and we are going to emphasize the things that worked, and we are going to stop the things that did not.

That is how innovation works in my industry.

The CHAIRMAN. Well, it is absolutely a fair point to say we are part of the problem by complaining when things do not work. And I think that is one of the lessons, at least, that I have learned in recent years.

I apologize for interrupting.

Ms. Cheney.

Ms. CHENEY. Thank you, Mr. Chairman.

Thank you to our witnesses.

Dr. Griffin, could you talk specifically, if hypersonics is our number one priority here, what are the main obstacles you see to a much more efficient, effective development of that technology? What are we doing about those obstacles?

And address, as you are doing that, whether or not our obligations—or, an interpretation of our obligations under the INF [Intermediate-Range Nuclear Forces] Treaty are having an impact on the research we are doing on hypersonics.

Secretary GRIFFIN. Let me take the last part of your question first, if I might, ma'am.

The INF Treaty, I think, does not hinder our ability to do research. It would color—the logical question is, why would you do research on systems which are capable of violating the INF Treaty? And my answer to that would have to be that our adversaries are already in violation, so I am not quite sure why we are observing the rules of a game that our adversaries have abdicated. I——

Ms. CHENEY. But would you say that we are observing the rules of the game with respect to——

Secretary GRIFFIN. So far, yes, ma'am, we have been. And I think that is a question for the Congress to deal with.

Now, with regard to systems that we can develop and how we can speed things up, we are on a test cycle where every few years we do an advanced hypersonic weapons experiment. We just did one with the Navy's Flight Experiment 1. FE–1 it is called. It was a brilliant success. I cannot praise them enough for how well they have done.

So, as the new Under Secretary for R&E, the question I am asking the Navy is, how soon can I have FE–2? And why are we talking about, you know, 18 months or 2 years or 2½ years? Why is it not August? That kind of pace of development as we work our way through the system problems to produce a realizable, operational system—we need to emphasize development pace.

These guys are doing great work. I do not have any suggestions to them to improve their work. I want it tomorrow. And I want to

know from them, what is your impediment to delivering the next test next August, so I can help you get that impediment out of the way.

Ms. CHENEY. And do you have a sense already of what some of those impediments are?

Secretary GRIFFIN. No, ma'am, other than what we have talked about here: our general culture of process, risk-avoidance, fear of failure. How many times do I have to analyze the system to be as sure as I can be that, when I do a test, it will not break, as opposed to a cultural mindset that says my greatest enemy is time, my greatest enemy is not breaking a piece of hardware.

I must add, ma'am, that I am often—every time I talk about regaining the kind of pace and speed that we used to be known for, people think I am talking about cutting out system engineering or testing or things like that. No, I am not. What I want to cut out is layers of bureaucratic decision making, where way too many people think that their opinion matters in the decision process.

I do not want to cut out engineering tests. I want to cut out the number of people who think they have a right to an opinion. Because that is how we are going to shorten the process. And if that sounds cruel, I am sorry, but that is what needs to go.

Ms. CHENEY. And do you have a sense, Dr. Griffin, that you have a willing audience in terms of the leadership of the Department? How will the process work from here in terms of making this kind of change that is a difficult one because it is a cultural change but, as you said, our greatest enemy is time?

Secretary GRIFFIN. I believe strongly that I have the unequivocal support of both the Deputy Secretary, whose experience in industry I much admire, and the Secretary, whose thought leadership in these areas is unparalleled. I cannot recall a better team.

Ms. CHENEY. And then, Dr. Schmidt, when you find a problem like, you know, the scavenger function you talked about, what is the system that is in place for you to be able to say, look, here is a problem, here is how we need to fix the overall process to address that?

Dr. SCHMIDT. So, by law, my group is called a FACA [Federal Advisory Committee Act] committee, so we are not allowed, by law, to implement anything. We are required to hold public hearings so we discuss it in public, and then we obviously want to speak to you. We have very good working relationships with the senior leadership in the DOD, who are listening to us. But we cannot cross the implementation line.

Ms. CHENEY. All right. Thank you. My time has expired.

The CHAIRMAN. Mrs. Davis.

Mrs. DAVIS. Thank you, Mr. Chairman.

Can I just clarify, Dr. Griffin, for a second—because I think you mentioned that people want to be heard. And they do. They believe their opinion is important. But there is also fear of accountability there, fear of, if I do not do this right, if I do not cross the t's, dot the i's—I mean, how can you smooth that process, which is, you know, we have to check all these boxes in order for me to be able to move this along? Is that something that can be done, can be changed?

Secretary GRIFFIN. Well, ma'am——

Mrs. DAVIS. How is it done?

Secretary GRIFFIN [continuing]. It can be done. We are, first of all, a sovereign nation, and the Department operates within that. We Americans make our own rules.

Mrs. DAVIS. Right.

Secretary GRIFFIN. So it is my best professional judgment that I can give you that, as regards engineering development, we have too many boxes to check.

Mrs. DAVIS. Yeah.

Secretary GRIFFIN. If we do not reduce the box checking, then we are never going to change the time.

Now, most of my career has been in government service one way or another, through laboratories and such, but I have about a decade, rounding off, in industry. And I can only tell you that there is a fundamentally different mindset. When you are in commercial industry, you are responsible for outcome. You are not responsible for process. Companies that become too bound up in process fail, and others win.

If we cannot in government—not just the Department of Defense—if we cannot in government become more focused on producing the outcomes we seek——

Mrs. DAVIS. Solving the problem.

Secretary GRIFFIN. Right, solving the actual problem, as opposed to proving that you went through the required process on your way to the failure, if we cannot change that mindset, then whichever member said earlier we had better learn to speak another language, I guess I am with him.

Mrs. DAVIS. Yeah.

Dr. Schmidt.

Dr. SCHMIDT. I have never seen it work any other way, that you get a group of people in a room with a whiteboard, or a blackboard in the old days, and you have a big food fight, and you balance all the various interests to achieve a clear outcome. That is how development is done. That is how it is done, slowly and quickly and with a sense of pressure and with creativity.

The military does not operate that way. That kind of behavior is in some cases illegal and is certainly frowned upon culturally. Indeed, what happens is there is a requirements process, and then there is a bidding process, and then there is a winner and a loser and a challenge, and then people are checking boxes and so forth. This is guaranteed to slow everything down. It is predictable that it would slow it down.

All you would have to do would be to allow the meeting that I am describing to occur. That is how innovation works.

When I talk to the military, they talk about what they view as a golden era, which, roughly speaking, think of it as the skunkworks period, where you would have—they describe a world, perhaps apocryphal, where in the 1970s you would have this plant and these people, and you would try this airplane and you would try that airplane, and this one crashed and this one worked, and they kept iterating very quickly.

That should be the mantra. And if that is not happening, there better be a good reason why we cannot develop in that model. And it seems to have been lost today.

Mrs. DAVIS. Uh-huh. So we have to try and fix it, Mr. Chairman.

The CHAIRMAN. You are right.

Mrs. Murphy.

Mrs. MURPHY. Thank you, Mr. Chairman.

Thank you, gentlemen, for your testimony today.

I represent a district in Central Florida that is home to what is called Team Orlando. It is a public-private partnership from modeling, simulation, and training [MS&T] that is co-located with the University of Central Florida, which is the second-largest university in the country and a major R&D institution.

Additionally, a key part of that ecosystem are a lot of these small businesses that are drivers of innovation in the MS&T and cyber industry. What I hear from them all the time is how hard it is to survive the long contracting lead time, not to mention CRs [continuing resolutions] and the impacts of those.

Recently, the Army just stood up a consortium called the Training and Readiness Accelerator, where we affectionately call it TReX, and it basically uses a flexible, alternative contract instrument called OTAs, or other transactional authorities, to field innovative research and prototypes. And they are trying to focus those fielding prototypes in areas where we need the most innovation—cyber training, artificial intelligence, medical modeling and simulation, those types of things.

Can you talk a little bit about how you think the Department of Defense should utilize OTAs and other unconventional acquisition methods to jump-start innovation? And, then, how can we ensure that these contract instruments are used to their greatest effect and managed properly?

Dr. SCHMIDT. So these OTAs have been around for a long time, and, indeed, the Congress has recently increased the number of OTAs. And yet the system that you are giving the OTAs is not using them very much compared to the opportunity before them.

So our team has recommended that, in fact, the military measure the use of OTAs and encourage the use in a measurement sense. If you set an objective, like if we are doing them a thousand times it needs to be doubled, I think that would make some progress to achieve the objective you laid out, which we agree with.

Mrs. MURPHY. Uh-huh.

Secretary GRIFFIN. Well, I certainly agree with all that. As to how they can be managed properly, I know of no better approach than to hire people that you trust to carry out a given development, put them in charge, and hold them accountable for the result. The whole purpose of an OTA is to reduce the box checking that Ranking Member Davis commented on earlier.

Mrs. MURPHY. Uh-huh.

Secretary GRIFFIN. So, again, measuring—the Congress gave us, the Department, enhanced permission to use OTAs. I think you should require us to use them and measure us on that.

Let me, however, add a parenthetical comment. The whole purpose of an OTA is to get around the system. Maybe we should just fix the system. I will leave you with that.

Mrs. MURPHY. Do you think there is a personnel element to why the OTAs are not being used to the full potential?

Dr. SCHMIDT. So, again, I would go back to this psychological problem, that the psychology of risk is set—the bid is set to "wrong." People should be promoted because they took risks. People should be promoted because they took risks, some of which failed, but enough of them won that the cause of whatever they care about was advanced greatly, right? And that is not in the language, in the military, in the HR [human resources] policies today.

Mrs. MURPHY. Uh-huh.

On another contracting personnel issue, you know, earlier this year, my colleagues and I were briefed on the F–35's continued sustainment problems, which are accumulating at such a rapid pace that the Air Force may be forced to reduce their plan by a third if sustainment costs do not fall significantly.

One of key issues that was highlighted in the F–35 sustainment report was a severe quality difference between industry contracting experts and those in the DOD that led to a contract that the Department still does not quite understand.

How can the Department of Defense develop the contracting experts necessary to negotiate better with the industry? And how important is this expertise in the future of U.S. defense innovation?

Secretary GRIFFIN. Well, Ms. Murphy, as I mentioned earlier, I do not have F–35 under me and have really very little knowledge of the program, so I——

Mrs. MURPHY. But I think this disparity is not just unique to the F–35. Could you speak about it more broadly, the disparity between the quality of contracting experts on the other side of the negotiating table from our DOD contracting?

Secretary GRIFFIN. I can only say that industry has a lot more money that they are allowed to spend on hiring lawyers and contracting officers than does the DOD. And it will always be a challenge for us to get people willing to work for civil service wages to go up against their corporate counterparts.

Eric mentioned earlier—and it is true—there are many, many, many very patriotic individuals who will take a salary cut to a small—that is, in effect, a small percentage of what they could earn in industry and come to work on behalf of the taxpayer to help retain the greatness that we have in this country. But not everyone will, and it is a difficult challenge. I cannot say more than that. It is a very difficult challenge.

Mrs. MURPHY. Great. Thank you.

And my time has expired. Thank you.

The CHAIRMAN. Dr. Wenstrup.

Dr. WENSTRUP. Thank you, Mr. Chairman.

Thank you, gentlemen.

We talked a lot today about increasing speed, as far as innovation. And one of things that you had said, if I heard you correctly, is one of the problems and challenges that we face is that so much technology is available to everybody; it is not really just ours.

And, to me, that is part of the problem that we face, whether it is intellectual property that is stolen, whether it is intellectual property that happens to be shared, whether it is property that comes from the commercial side rather than out of, say, the Department of Defense or wherever.

So those are some of the challenges we face. So increasing speed, I guess that helps, but it does not help a whole lot if it is immediately available to everybody else, including your adversaries.

So, in this process, what recommendations do you have of how we protect ourselves with what we do come up with? And where do you see the pitfalls today?

Secretary GRIFFIN. Well, I guess I can go first.

There are certain technologies that are and should be highly classified and certain programs that we do that are and should be highly classified that we should try to wall off from others, and we should make sure that we are successful at that.

But I will offer—you are asking for a conclusion of the witness, and I will offer my opinion that the way to get ahead and stay ahead is to work harder and run faster. Even if we have a technological edge in a particular area—you can name the area—even if we have an edge, once an adversary knows that a certain thing is possible to do, even if they do not have exactly the same intellectual property that we used to do it, they will figure out a way. If they are intent on dominating us, our only recourse—our only recourse—is to work harder and run faster and stay ahead.

And that is best enhanced by a free and open interchange of market technologies, the unhindered flow of capital and people to businesses that are successful and DOD enterprises that are successful, and, as Eric mentioned earlier, stopping those things that are not working. If we cannot be more agile than our adversaries, then in the long run they will win. I cannot say it another way.

Dr. WENSTRUP. No, I get that completely. I guess my question is, are we doing enough to slow down their speed, our adversary's speed, I guess? You know, you called it walling off. Is it really walled off, or is everything just getting out?

Secretary GRIFFIN. You cannot wall things off, sir, not permanently.

Now, there are some things—there are a few more progressive news magazines than The Economist which championed, as I well remember, China's admission to the World Trade Organization a couple of decades ago. They now, just a few months ago, had an extensive article on Chinese practices of holding corporate IP [intellectual property] hostage if a corporation wants to manufacture in China. This is an unfair practice. Until and unless the United States and our allies are willing to push back on such practices, we will be handing IP over to an adversary.

So there are some things we can do, but, broadly speaking, if we are not prepared to work harder, run faster——

Dr. WENSTRUP. Right. Right.

Secretary GRIFFIN [continuing]. And compete at the technological edge, then we will not win.

Dr. WENSTRUP. And I understand what you are saying, that they are going to catch up at some point anyway. But the point is to stay ahead. And so I think you were, in a way, making a recommendation there that we do not allow this to happen so readily and so quickly and so easily, for, say, China to inherit our information and technology.

Secretary GRIFFIN. Yes, sir, that is correct. I certainly think we should be not doing deals in which giving up our IP is contingent to the deal. That does seem remarkably shortsighted.

Dr. WENSTRUP. Thank you.

I yield back.

The CHAIRMAN. Mr. O'Halleran.

Mr. O'HALLERAN. Thank you, Mr. Chairman.

And thank you——

The CHAIRMAN. Is your microphone on?

Mr. O'HALLERAN. There we go.

I would like to echo the ranking member's comments about the importance of developing tomorrow's technology and defense leaders through investments in STEM education and other programs that promote innovation.

During your testimony today, you made some observations that I found extremely interesting. One of the issues we have talked about today is workforce and that it not only addresses the current issues but the future issues as we move forward; and the needs, additionally, for the DOD in areas like AI, which, you know, I was using consultants on AI in the late 1980s, so I do not understand why we have not moved ahead faster on this area; cyber, where we have had people in here this year to address us, and they have indicated that by 2025 we need another million people, both private and government, in that area; and other things that we have not even thought of right now.

And you have mentioned about the universities. And our universities are great universities, but they are only going to be as good for us as the people that we send to them. And I believe that we cannot afford, as a country, to leave people behind that have the knowledge potential but lose it because of inability to get the type of education they need.

And then we have talked here in committee, time and time again, about the all-of-government approach. And we do not seem to have the all-of-America approach to issues.

So we have critical barriers in developing a high-tech workforce. Nearly 20 million Americans and one-quarter of rural communities do not have access to broadband. Lack of broadband access affects the ability of meaningfully expanding STEM initiatives in those areas and impacts businesses across the industrial base in rural areas. I believe without addressing this key infrastructure priority, our shared goal of sharing defense-related innovation among non-traditional and small businesses will not achieve its full potential.

I also believe that if we do not clearly identify that our—whether it is preschool and to high school, that this transition is not—right now, it is not working for America, and we need to find a way to get that to work.

I would like to ask the witnesses how the digital divide and lack of broadband impacts the culture of innovation at the Department of Defense and believes that it is necessary for today and tomorrow's national security.

Thank you.

Dr. SCHMIDT. No, thank you.

The issue of broadband is crucial to economic growth in our country, to educational growth, to societal growth. There are groups still left behind.

There is tremendous work in using licensed and unlicensed radio waves to achieve the last-mile problem in rural areas. So I have good news, that I think that in the next some number of years we will overcome even those challenges. It started in 1996 with NetDay, when we wired up the schools; 20 years later, I think we are getting very close to it.

I agree with your comment. Part of the reason that broadband is so important is that, on the educational side, which is what really affects the military, there are new tools and techniques being developed using AI for direct and personal learning which are available over broadband networks that are interactive and interesting and game-ified and so forth.

So there is a possibility of reaching the most isolated and most disadvantaged person, you know, citizen who can really benefit from this in a way that can materially affect their careers, their quality of life, their education, and their suitability for military service.

Mr. O'HALLERAN. Mr. Griffin.

Secretary GRIFFIN. Well, if there is anyone more in love with education than I, you would have to struggle to find him. So I agree with everything that has been said.

You know, we need to do a better job of preparing our high school students to go to college. I have spent time as a college professor, and I would agree with the observation that our high school students are not coming to college as well-prepared as they once were and that we should fix it. And one of the ways to fix that does involve broadband access for everybody. That is the modern world.

Mr. O'HALLERAN. Thank you.

And I yield.

Secretary GRIFFIN. And I do not know what the Department can do specifically, but I support your goals.

The CHAIRMAN. Mr. Khanna.

Mr. KHANNA. Thank you, Mr. Chairman.

Thank you, Dr. Griffin, Dr. Schmidt, for being here, for your service to our country. It is heartening to see a physicist, a technologist, answering the Nation's call to public service.

Dr. Schmidt, in your book "The New Digital Age," you and Jared Cohen anticipated a lot of the issues that we face today. You talked about data permanence and the problem with data permanence. You talked about the need for internet privacy.

I agreed with your statement, Dr. Schmidt, about the technology competence in the Department of Defense, and I think Dr. Griffin cited the same thing. But I wonder, candidly, what both of you thought and whether you shared the dismay and, frankly, embarrassment that most Americans had, as they watched the Senate hearings and some of the Senators questioning Mark Zuckerberg, about the technology gap in the United States Congress and whether there are things we could do to help improve that.

Secretary GRIFFIN. I did not see the hearing and was not aware of it, and so I cannot offer you a useful comment, sir. I am sorry.

Dr. SCHMIDT. I, too, did not watch the hearing. I am sorry.

Mr. KHANNA. Are there things, you think, that—do you think the United States Congress could improve our knowledge about technology?

I mean, just to give you a sample, one of the Senators asked Mark Zuckerberg how does he make money on Facebook when he does not charge for the services. Another Senator did not know what cookies were. I mean, I can go through it.

And I am not saying this in a disparaging way. I am just wondering, do you think—you have talked about the education. Do you think the United States Congress, to be able to deal with matters of defense and artificial intelligence, could use a better education?

Dr. SCHMIDT. Well, I can say that the areas that we are describing now are pretty technical, and I would not expect an average citizen in good standing to understand them a priori. I do think that more briefings, for the benefit of the Congress, of the impact—I will pick my favorite area, artificial intelligence—would be helpful so that the leaders of our Nation can understand the good, the bad, the restrictions, what they are good for, what they are bad for, and their implications.

My industry, as you know very well because you represent us, is gaga over AI and the application of it in our businesses. And it is important that our leaders understand the implications of all of that.

Secretary GRIFFIN. I mean, broadly speaking, I think most of us are aware that having educational and cultural and all kinds of diversity in decision-making groups aids the decision making. The more disparate points of view you can bring to a task before you have to actually make a decision, generally the better you will do. And so, if more working scientists and engineers and medical doctors and such ran for Congress, I think that would broadly be a good thing.

But, you know, when—and I have had many years now of working with the Congress, and I do not generally find that the issues confronting us are caused by a failure of the Congress to understand what we are saying. The issues seem to be more systemic, as Dr. Schmidt was pointing out earlier. I could not choose better words, and so I will just try to quote him as best I can. We have great innovators in the Department that are trapped within a system that really does not work.

As Winston Churchill famously said about democracy, it is the worst of all systems except for all the others we have tried. Some of these things seem to be just endemic to the nature of representational democracy, and we struggle on to do the best we can.

Mr. KHANNA. If I could ask one final question, and then I will give you both the last word.

Dr. Schmidt, in your book, you did talk about privacy and regulation of privacy. And that is probably, as we are dealing with artificial intelligence and all the positives, probably more important than ever.

Congresswomen Anna Eshoo, Zoe Lofgren, and I have been thinking about what an internet bill of rights would look like, something maybe not as expansive as the GDRP [General Data Protection Regulation] but within the American context.

I wonder if you and Dr. Griffin have thoughts about how to get technology leaders part of that conversation and behind an idea that would assure the American public that the Congress can protect their privacy around some internet bill of rights in a bipartisan way.

Dr. SCHMIDT. So there have been a number of attempts at doing this. And I think many people are sympathetic to the idea that you are proposing. The devil is in the details, as you know from being a legislator. And so I would encourage the three of you to work hard—you all know our industry very well, and you try to represent the Nation as strongly as you can—to try to find that balance.

In our book, which was some years ago, we said you need to fight for your privacy or you will lose it. And I remember writing that sentence because it is so easy for the public information about you—or the private information about you to become available to the public without your knowledge. And I think there must be a way to enshrine that principle with the right balance between interests.

Mr. KHANNA. Thank you.

The CHAIRMAN. Dr. Schmidt, let me ask one other question that occurs to me. We have talked about much of the innovation in the country occurs in the private sector. Especially for small businesses, it is hard to do business with DOD.

But since you have a foot in both camps, what is the willingness of, say, the IT industry to do business with the Department of Defense? Is there a reluctance?

Dr. SCHMIDT. Well, there is a general interest in doing business with the DOD. There is a general fear that the overhead costs will kill the startup.

And it would be very helpful if we had a number of companies that had started with an idea, had help from the DOD to get through the process, and had ultimately become hugely successful in the new paradigm. And if we had a couple companies like that that we could point to in our narrative, I think that would encourage more of that.

You know, the venture industry is a hits business, and so we need a couple of hits of companies that are good businesses that have also served the DOD in the things that it cares about. DIUx is an attempt at that. There are other initiatives within the DOD to do that. But we need a couple big wins.

May I add, I wanted to say something to all of you, that it is important not to feel helpless when you are in our situation but, rather, be clear and assertive that this is a system, as Mike said, that operates under the laws of our Nation; we can change it.

So we have highlighted a couple of examples of things which do not make any sense when you are in the middle of a system—right? If I could paraphrase you, it just does not make any sense.

Secretary GRIFFIN. Exactly.

Dr. SCHMIDT. Why do all of us not collectively engage in a discussion as to how we could eliminate some of those nonsensical behaviors, right, and at least have that debate?

It feels like that debate is not occurring, to me. As a private citizen, it feels like everybody is sort of repeating the old criticisms—

well, this contractor screwed up, or this procedure was a problem—rather than saying, this system was not architected. How would we architect a system to address at least the stupid stuff?

I assume you are okay with that.

Secretary GRIFFIN. Again, I could not agree more. Eric and I have a remarkably consistent alignment.

I simply know that, when developing new things that have not been done before, it is hard to get it right, it is easy to make mistakes along the way, and when you are doing it, you are guided by a single-minded focus on the end goal. But when I am doing that, I cannot tell you up front what the requirements ought to be, exactly how it is going to come out in the long run, what contractors I need, what people I need, what system practices I am going to use. It depends.

And so, if in the advanced development stage—which I will say includes things up through operational prototype so that real operators can have some experience with the thing before deciding to go into production—if up through the operational prototyping phase you can give the Department as much flexibility as possible to not know exactly how we are going to get to the goals we all share, give us the flexibility to not know how we are going to get there, and hold us accountable for outcomes instead of processes, that is the best thing that you can do.

Thank you, sir.

The CHAIRMAN. That is helpful.

The only thing I would quibble with you a bit about is, I do not think it is business as usual at this point. My sense is we have a combination of leadership at the Department that is committed to reforms. We have more bipartisan interest in Congress committed to reforms. And I have this sense of urgency, that you all have described in another sense, that this is a chance to improve our processes. Now, none of us will be satisfied, it will not go far enough, but we have an opportunity here that, with you-all's guidance and a little willpower, we can make significant improvements.

And so that is one of the reasons that I wanted to have this hearing in public today. I appreciate very much both of you being here. And in about 5 minutes or so, we will continue our discussion in classified session upstairs.

The hearing stands adjourned.

[Whereupon, at 12:05 p.m., the committee proceeded in closed session.]

A P P E N D I X

April 17, 2018

PREPARED STATEMENTS SUBMITTED FOR THE RECORD

April 17, 2018

House Armed Services Committee Chairman William M. "Mac" Thornberry
Statement for the Record
Hearing on "Promoting DOD's Culture of Innovation"

April 17, 2018

For the last three National Defense Authorization Acts, reform, especially acquisition reform, has been a major priority. The purpose has been to get more value for the taxpayers out of the money spent, but even more importantly to make the Department more agile in dealing with the variety of security challenges we face.

As Secretary Mattis has testified, our technological position has eroded in recent years compared with our leading adversaries. We confront threats that do not conform to our traditional notions of warfare. And the historical evidence indicates that we may well be a victim of our own success.

As one writer put it when looking at the interwar years, "the losers were forced by events to reexamine everything. Military losers are intellectual radicals; the winners, complacent in victory, feel the need for self-examination far less. Thus, for the French, the lesson of World War I was that offensive warfare could not succeed."

The answer is that the Department of Defense must work to be more innovative in technology, in policies, and in thought. One of the many books offering advice to businesses sums it up with a chapter title that is, "Innovate or die." That has been the goal of the reforms of recent years and of the reform proposals for the FY'19 NDAA that I am releasing today.

We are privileged to have two witnesses who are superbly qualified to help guide our efforts as well as the Department in the quest to develop a culture of innovation. One of the reforms we enacted two years ago was to create an Undersecretary for Research and Engineering to be the primary driver of innovation in the Department.

Dr. Michael Griffin was confirmed in that position about two months ago and among things is formerly the Administrator of NASA.

Dr. Eric Schmidt is the Chairman of the Defense Innovation Board and formerly Chairman and Chief Executive Officer of Google and its parent Alphabet, where he remains a technical advisor. He is here, however, only in his capacity with the Defense Innovation Board.

House Armed Services Committee Ranking Member Adam Smith
Statement for the Record
Hearing on "Promoting DOD's Culture of Innovation"
April 17, 2018

I appreciate the Chairman calling today's hearing on the need for more innovation in technology development in the Department of Defense.

Innovation is a broad term that gets thrown around a lot, but, to me, the most important aspects of innovation are promoting a culture of openness, looking for new ways to do things, being willing to accept prudent risks in trying something different, and constantly looking ahead rather than behind.

Maintaining a culture of innovation matters. Broadly speaking, a culture of openness and innovation contributed greatly to the United States' defeat of the Soviet Union in the Cold War, including innovation within the Department of Defense. Harnessing innovation in the private sector, both through bringing bright people into the DOD and working directly with industry, enabled the United States to gain and maintain a technological edge in many areas. The story of technologies spinning out of the space race in the '60s is well known. Similarly, DOD investments in early internet technology were critical. Many efforts coming out of Silicon Valley over the last few decades actually started with funding from the DOD or other government sources. Simply put, the DOD has a long history of innovation that we need to keep in mind as we move forward. We've been here before, and succeeded before, so if the right resources and attention are applied, we can do it again.

However, if the U.S. is to remain a global leader in technology, we can't just play defense and hope for the best. Efforts to maintain a technological edge are absolutely critical, as are investments in science and research, prototyping, and other development efforts to maintain and advance warfighting capabilities. No less important are investments in STEM education, programs that develop junior talent into future tech leaders and policies that promote an environment in which global collaboration, discovery, innovation, public institutions and industry can thrive.

Clearly, this cannot be done by DOD alone. However, DOD has a significant role to play as a customer and driver of innovation. DOD's S&T ecosystem includes science, technology, and reinvention laboratories that house some of our country's greatest assets and people. It also includes DARPA, which has invested in some pie-in-the-sky ideas that came to fruition and changed how we fight and how we live. Over the course of many years, Congress has worked to provide authorities and legislation that enable these institutions to be utilized to their fullest potential by the Department. In today's hearing, I hope to hear more about how DOD needs to change to innovate in the technology areas we know are going to be vital in the future, such as robotics, artificial intelligence, and directed energy. America and the DOD have a long history of innovation, we just need to reenergize the institution to get where we need to go.

STATEMENT BY
DR. MIKE GRIFFIN

UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

BEFORE THE

HOUSE ARMED SERVICES COMMITTEE

ON

PROMOTING DOD'S CULTURE OF INNOVATION

SECOND SESSION, 116TH CONGRESS

APRIL 17, 2018

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BY THE COMMITTEE ON ARMED SERVICES
UNITED STATES HOUSE OF REPRESENTATIVES

Promoting DoD's Culture of Innovation

Chairman Thornberry and Ranking Member Smith, thank you for the opportunity to testify on this incredibly important subject.

The United States Military remains the best fighting force in the world. We are proud of our men and women who are willing to make the ultimate sacrifice for our country, and we do everything possible to provide them with the absolute best training, equipment, and medical care possible. Despite all our efforts, we are constantly challenged to maintain science and technology superiority.

For decades, our adversaries have studied our methods and invested specifically in capabilities that mitigate our strengths. They have witnessed our equipment, watched our tactics, techniques and procedures, and learned our concepts of operation. Unfortunately, and as expected, our adversaries continue to exploit our weaknesses. They are systematically and strategically developing and fielding advanced systems more rapidly than us. This erodes the advantage that DoD has maintained in conventional warfare and impedes upon our ability to project power.

The incremental democratization of technology has fostered global and easy access to cutting edge capabilities, which has in turn contributed to the ability of our adversaries to achieve technology parity. As a result, our military's advanced technical capabilities and unmatched technological superiority is being challenged by the investments of competing powers. Given the leveled playing field, speed in developing new technologies and delivering capabilities to the warfighter is more critical now than ever.

In this increasingly competitive environment, the Department must pay much more attention to future readiness and regaining our Joint Force conventional overmatch. We must be willing and able to tap into commercial research, recognize its military potential, and leverage it to develop new capabilities, while also accounting for the operational and organizational constructs to employ them faster than our competitors.

The department has realized rapid technological developments in advanced computing, big data analytics, artificial intelligence, autonomy, robotics, miniaturization, additive manufacturing, meta-materials, directed energy, and hypersonics. These are the very technologies that ensure we will be able to fight and decisively win the wars of the future.

Many of these advances are driven by commercial sector demands, as well as research and development. New commercial technologies have the potential to change society, and in turn change the character of war. The fact that many technological developments will continue to come from the commercial sector means that state competitors and non-state actors will also have access to them, eroding the conventional overmatch our Nation has grown accustomed to.

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

Determining Strategic Priorities in a Global Context

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

Immediate threats to our security are apparent, as our adversaries and malignant actors use all instruments of power projection to shape societies, markets, international rules and institutions, and international hot spots to their advantage. To ensure a global society governed by ethical and rules-based institutions, it is vital the U.S. remain engaged and prepared for any and all contingencies. We must develop new lethal capabilities and accelerate the pace in which we get that capability to the warfighter to ensure our qualitative military edge.

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

To ensure warfighters have what they need, we have to continue to engage with them. The USD(R&E)'s mission is to work with operations to develop new concepts of operations through mission analysis and experimentation, and pilot new acquisition pathways to speed up delivery of capability to the warfighter. It is important for our enterprise to utilize intelligence products, technology forecasting, and analysis to inform decisions on technology investment, prototyping, experimentation, emerging capabilities, and concepts of operation. We will focus on driving effectiveness and affordability by addressing drivers in acquisition, testing, and sustainment into the system design phase, setting and adhering to open architectures and interface standards while implementing best systems engineering and cyber resiliency practices.

We continue to pursue breakthrough research into new technologies, including autonomous and unmanned systems, artificial intelligence, biotech, cyber, electronic warfare, and hypersonics, among others, to preserve the U.S. technological advantage. These technology focus areas are not just important to the Department of Defense, they are the focus of global industry. Many of these efforts are maturing rapidly and are likely to offer viable partnering solutions to enhance warfighter capabilities in the near term. Identifying centers of excellence to spearhead investment portfolios is a way to maximize our agility in innovation and to pursue diverse investment strategies. Several of the Department's initiatives (i.e., the Army Research Lab Open Campus, the Defense Innovation Unit-Experimental (DIUx), and the pilot program with In-Q-

Tel) are expanding avenues to grow Department and industry partnerships. Beyond technical innovation, the Department continues to pursue new practices and organizational structures to support a culture of innovation.

DoD's Culture of Innovation

The Department relies upon the science and technology (S&T) enterprise to research, develop, and demonstrate high pay-off technology solutions to the hard problems faced by our Warfighters in ever-changing, complex environments against an increasingly diverse set of threats. To do this, the R&E enterprise is pursuing solutions that are innovative, affordable, and versatile to ensure that our military remains the most capable in the world.

Given the breadth and depth of our competition, we are forced to stay vigilant in our efforts from basic research to advanced capabilities. The DoD R&E enterprise exists to provide the technological foundation that ensures the U.S. military of both today and tomorrow is the most capable in the world. DoD is pushing the envelope with innovative and cutting edge research coupled with new approaches to solving problems in order to ensure U.S. technical dominance.

The Department has long relied on high quality people, world class technological capabilities, innovative operational and organization constructs, and our unmatched ability to fight as a joint force. The Department's current focus on technical innovation reflects the belief that maintaining technological superiority is critical to the future security of the United States and its allies. Technological superiority directly correlates with healthy defense laboratories, a robust industrial base, sound technology investment decisions, stable and adequate budgets, and an effective defense acquisition system.

In my role as USD(R&E), I am charged with setting the Department's technical direction, addressing critical warfighting challenges, and enabling more rapid delivery of solutions to stay ahead of the threat for all warfighting domains. To achieve this, I am focusing on ensuring that the department strikes an appropriate balance between funding innovative, disruptive basic research likely to see long-term returns on investment and addressing near-term operational needs and military requirements. Our modernization efforts require that both short and long term needs to be addressed. These efforts are categorized into mission-focused and technology-focused efforts. Our mission-focused modernization efforts are Fully Networked Command, Control & Communications, Space Offense and Defense, Missile Defense – Evolved Midcourse and Airborne BPI, Cybersecurity – Offense and Defense, and Nuclear Modernization. Our technology-focused modernization efforts are Hypersonics (both Offense and Defense), Directed Energy, Machine Learning (Artificial Intelligence), Quantum Science (Including Encryption and Computing), and Microelectronics. In all of these areas, we are establishing near, mid, and long term goals that are measurable.

One of my key priorities is to enable the Department to drive the military innovation cycle faster than any adversary to sustain technological superiority. Our competitors are closing the gap because of our processes, not our talent. We are striving to both develop innovative capabilities AND be innovative in our processes. We have already proven our willingness to adapt and open the aperture to new sources of ideas. The Department continues to cultivate new mechanisms to

reach non-traditional partners, such as grants to universities, industry partnerships, experiments, and other mechanisms that engage a broader community.

DoD has the third largest investment among Federal agencies in Basic Research at U.S. universities, who have, through years of continued investments, been the source of many of today's transformational Warfighter technologies. Traditionally, the Department has viewed the role of universities as producing the research innovation, the DoD labs as the mechanism to nurture these findings and to render them Defense-applicable, and the Defense Industrial Base to integrate these new technologies into acquisition programs. The Department is currently exploring opportunities to consider less linear processes and to have more cross fertilization between these communities. DoD also funds university researchers in areas that have military-relevance or may eventually impact capability development of military relevance. These researchers maintain a close and continuing relationship with the DoD and serve as an outside source of innovative capabilities.

Investments in efforts such as the Strategic Capabilities Office (SCO) and the Defense Innovation Unit Experimental (DIUx) have enabled the department to reach to non-traditional sources of innovation and collaborate with industry. SCO continues to rapidly identify, prototype, and transition game-changing applications of existing technology and capabilities that counter near-peer adversaries and address Combatant Commanders' top priorities. SCO is a critical investment in achieving near-term technology superiority over our adversaries, and is an inherently innovative effort to rethink and repurpose existing capabilities. DIUx has been successful in leveraging and facilitating commercial technologies coming from sources traditionally not available to the Department, with the ultimate goal of accelerating those technologies into the hands of warfighters. They have engaged hundreds of non-traditional companies across the country to compete for contracts with DoD. DIUx has been highly successful in reenergizing private sector interest in working with the DoD.

Enabling the transformational capabilities needed to meet emerging Joint Force challenges requires innovative business practices to provide the speed and agility necessary to outpace our adversaries' capabilities. The department has already made strides in this arena, such as initiating a RDT&E program of $1million for the Defense Digital Service (DDS), which will apply best-in-class private sector practices, skills, and technology to transform the way software products are developed and delivered for the DoD. The DDS is charged with examining the way the Department works with cloud-based services and to think more deliberately and innovatively about cloud and information technology implementation practices and policies. In addition, efforts of DIUx and other Service-specific rapid capabilities offices have increased the utilization of Other Transaction Authorities (OTAs), speeding up the contracting process and leveraging previously underutilized authorities granted to the DoD. One of the greatest second-order effects of the use of OTAs has been the increased linkages between the contracting staff and the S&T mission, improving the seamlessness of our processes.

The Department is investing in war gaming, operational exercises, and intelligence collection for projected adversary threat systems and continues to emphasize the use of prototyping, demonstrations, experimentation, and game-changing technology. For instance, the Army Technology Maturation Initiatives program is conducting experimental prototyping and

demonstration of selected technology enabled capabilities to support advanced ground systems, aviation systems, command, control, communications and reconnaissance systems and equipment, precision weapons, high energy laser systems, and soldier equipment.

Additionally, the Navy Rapid Prototyping, Experimentation, and Demonstration and Advanced Combat Systems Technology programs are exploring fleet-proposed capability concepts and enabling technologies, such as directed energy weapons, hypersonics, unmanned systems, artificial intelligence, and machine learning. The Air Force Technology Transition program is conducting experimentation and prototyping efforts to stimulate and explore new innovative concepts and their applications in potential future operating environments and accelerate future concepts and technologies into acquisition programs and/or operational use while mitigating technical and integration risk.

Large-scale experimentation sponsored by R&E has significantly accelerated the fielding of capabilities by concurrently exploring myriads of potential approaches in operationally realistic conditions with the level of complexity and fidelity that Service/Industry developers could not otherwise replicate. One example of this is the Black Dart experiment in 2007-2010, which sought to improve capabilities to detect, track, and engage UAS threats and obtain data on commercially-available and state-sponsored small UAS. The experiment demonstrated novel detection, kill, and EW interdiction capabilities, and transitioned to the Joint Integrated Air and Missile Defense Organization (JIAMDO) thereafter. The Services all leverage experimentation to explore the full range of innovative and possible solution options across the doctrine, organization, training, materiel leadership, personnel facilities, and policy spectrum.

Conclusion

Fostering a culture of innovation in the DoD is occurring through both innovative business practices and innovative capability development. Every day, the enterprise seeks to leverage in new ways the diverse knowledge, skills, and ideas of DoD's research and engineering personnel and organizations. Global trends and fast-moving competitors are threatening the U.S. military's technological dominance. To sustain U.S. technological superiority in coming decades, the DoD R&E Enterprise will continue to work in unison to leverage our unmatched strengths and the innovative talents of our people to develop innovative capabilities that will be decisive in future conflicts. We are striving to eliminate performance obstacles and enable and empower the Department's intrinsic creativity and ingenuity through deploying transformative business practices that strengthen and grow our workforce's talents and skills, while also speeding up the discovery, development, and transition of breakthrough science and technology to our warfighters.

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

Dr. Michael D. Griffin
Under Secretary of Defense for Research and Engineering

Dr. Michael D. Griffin is the Under Secretary of Defense for Research and Engineering. He is the Department's Chief Technology Officer, and is responsible for the research, development, and prototyping activities across the DoD enterprise and is mandated with ensuring technological superiority for the Department of Defense. He oversees the activities of the Defense Advanced Research Projects Agency, the Missile Defense Agency, the Strategic Capabilities Office, Defense Innovation Unit Experimental, the DoD Laboratory enterprise, and the Under Secretariate staff focused on developing advanced technology and capability for the U.S. military.

Mike was previously Chairman and Chief Executive Officer of Schafer Corporation, a professional services provider in the national security sector. He has served as the King-McDonald Eminent Scholar and professor of Mechanical and Aerospace Engineering at the University of Alabama in Huntsville, as the Administrator of NASA, and as the Space Department Head at the Johns Hopkins University Applied Physics Laboratory. He has also held numerous executive positions in industry, including President and Chief Operating Officer of In-Q-Tel, CEO of Magellan Systems, and EVP/General Manager of Orbital ATK's Space Systems Group. Griffin's earlier career includes service as both Chief Engineer and Associate Administrator for Exploration at NASA, and as the Deputy for Technology at the Strategic Defense Initiative Organization. Prior to joining SDIO in an executive capacity, he played a key role in conceiving and directing several "first of a kind" space tests in support of strategic defense research, development, and flight-testing. These included the first space-to-space intercept of a ballistic missile in powered flight, the first broad-spectrum spaceborne reconnaissance of targets and decoys in midcourse flight, and the first space-to-ground reconnaissance of ballistic missiles during the boost phase. Mike also played a leading role in other space missions at the John Hopkins University Applied Physics Laboratory and NASA's Jet Propulsion Laboratory.

Griffin has been an adjunct professor at the University of Maryland, Johns Hopkins University and George Washington University, teaching spacecraft design, applied mathematics, guidance and navigation, compressible flow, computational fluid dynamics, spacecraft attitude control, estimation theory, astrodynamics, mechanics of materials, and introductory aerospace engineering. He is a registered professional engineer in California and Maryland, and the lead author of some two dozen technical papers and the textbook Space Vehicle Design.

He is a member of the National Academy of Engineering and the International Academy of Astronautics, an Honorary Fellow and former president of the American Institute of Aeronautics and Astronautics, a Fellow of the American Astronautical Society, and a Senior Member of the Institute of Electrical and Electronic Engineers. He is the recipient of numerous honors and awards, including the NASA Exceptional Achievement Medal, the AIAA Space Systems Medal and Goddard Astronautics Award, the National Space Club's Goddard Trophy, the Rotary National Award for Space Achievement, the Missile Defense Agency's Ronald Reagan Award, and the Department of DoD Distinguished Public Service Medal, the highest award which can be conferred on a non-government employee.

Griffin obtained his B.A. in Physics from the Johns Hopkins University, which he attended as the winner of a Maryland Senatorial Scholarship. He holds master's degrees in aerospace science from Catholic University, electrical engineering from the University of Southern California, applied physics from Johns Hopkins, civil engineering from George Washington University, and

business administration from Loyola University. He received his Ph.D. in aerospace engineering from the University of Maryland, and has been recognized with honorary doctoral degrees from Florida Southern College and the University of Notre Dame.

Mike is a 4000+ hour commercial pilot and flight instructor with instrument and multiengine ratings, and holds an Extra Class Amateur Radio license.

Statement of Dr. Eric Schmidt
House Armed Services Committee
April 17, 2018

Mr. Chairman, Ranking Member, and distinguished members of this committee, thank you for the opportunity to appear before you today to testify on the state of innovation in the Department of Defense (DoD). Today, I am testifying in my personal capacity as an interested citizen, not as the Defense Innovation Board (DIB) Chairman, nor as a board member of Alphabet, Inc. My remarks also do not necessarily reflect the views of the Department.

Since joining the DIB in 2016, my fellow board members and I have traveled around the world, visiting dozens of military facilities and installations, and engaging with hundreds of service members – from senior commanders to our men and women in the trenches. Coupled with our collective expertise and experience, these engagements inform the Board's official recommendations aimed at providing the Department with tangible proposals to tackle diverse challenges. They also inform my testimony today.

I consistently meet brilliant, creative, entrepreneurial people in DoD with novel and implementable ideas, but they are fighting against entrenched processes and regulations that – in some cases – haven't been modified in decades. Incentives are often misplaced. Decision-making seems surprisingly diffuse for an organization known for its hierarchical structure and decisive leaders. Some of these *intrapreneurs* find workarounds to inflexible systems or receive temporary shelter under a like-minded commander; far more do not. Even the most senior leaders described responsibilities being so intricately nested across the organization that a sense of true ownership proved elusive to them. Early on, I reached a fundamental conclusion that has been borne out over time: DoD does not have an innovation problem; it has an innovation *adoption* problem.

In a sense, this is understandable. The growth in size and complexity of the Department's mission and systems has contributed both to the increased friction and latency in its decision-making processes and has driven a demand for additional layers of coordination mechanisms. And over time, every lapse in judgment or performance accretes further rules, regulations, or procedures aimed at preventing errors. Yet, the cumulative effect appears to be disempowering for many, even for those engaged on the frontlines of conflict. It is troubling to consider that good ideas were not implemented because of prevailing norms that reward perfunctory compliance or reticence of supervisors to consider new approaches. It is even more frustrating to see passionate service members choosing to leave the military after being continually stymied by these structures.

It is not will, but inertia, that hinders innovation. Most people who protect the *status quo* are motivated by a sincere desire to protect vital institutions that they hold dear. In my view, the Department tends to overestimate the benefits of consensus, stability, and transparency at the expense of speed and agility. This has produced a culture that prioritizes compliance over results and favors consistency over ingenuity. When there is relatively little benefit for entrepreneurial results, but grave potential consequence for entrepreneurial risk, there is little

incentive to serve as a change agent. As one of my Board colleagues often says, "process does not trump competence," and DoD must make that axiom true in our self-assessments and personnel practices.

The Need for Speed

If there were one variable to solve for it would be speed. For decades, DoD has sought to field the "perfect" system to put into the hands of service members, hewing to the notion that superior quality would deliver enduring strategic advantage. Today, that goal largely remains, with some exceptions. I've found the Department to rely on the requirements process as a key driver of technological progress, and as a way to manage increasing complexity and ensure incremental gains across multiple systems. That requirements process is now the single greatest barrier to rapid technological advancement.

DoD built a system that assumed it was the prime mover in defense-relevant sectors, and that the world would wait for a perfect answer from the requirements process. This logic held for nuclear weapons, stealth, and precision weapons. But the world waits no longer, and organizations that take years to develop a capability incur the risk of failure. Some argue the Department is risk-averse - I see it differently. DoD assumes a massive amount of risk, but pushes this risk out of the headquarters and onto the battlefield, where service members must wait years before accessing current technology. While change has inherent risk, I believe there is more at stake by maintaining the *status quo* in the face of quickly-evolving security threats and adversaries that are accelerating their technological advancement.

Today, the private sector, not government, is developing the most critical technologies from which modern weapons systems are deriving the most significant advantage. Software and processing speed drive the leading edge of complex weapons systems today, including electronic warfare, cyber, space-based systems, algorithms and machine learning for sensor fusion, the proliferation of unmanned systems and autonomy, and so forth.

With this in mind, everyone in the world - including U.S. competitors - has equal access to this technology. But a slow-moving requirements process intended to maximize consensus among users and drive precision into the defense industrial base does more to hinder rapid adoption of commercial technologies than it does to facilitate it. Improved software engineering and a focus on artificial intelligence (AI) will accelerate DoD's speed, but only if the Department invests enterprise-wide resources towards this effort.

While many senior leaders I have spoken to recognize this truth and have begun to integrate these ideas into their messages to the force, it is a massive undertaking to overturn decades of deep-rooted processes that impede a shift toward becoming the "fastest follower." A number of organizations in DoD are adopting proven approaches seen in industry and academia and deserve mention here because they are the most promising examples of defiance to the prevailing systems.

Innovation Success Stories

Part of the Board's mission is to identify promising examples of innovative behaviors and activities to better understand how to spread these practices by both studying and celebrating them. I have encountered a few dozen excellent examples of DoD teams and leaders that are trying – and succeeding – to adopt new approaches and change the culture in their respective organizations. Below is a sampling of just a few of these examples:

The Defense Innovation Unit Experimental (DIUx) opening of offices in key innovation ecosystems around the country two years ago is the main reason why the Department is again considered a viable customer to the commercial innovation ecosystem today. DIUx accomplished this in three ways: first, by rebuilding and fostering relationships with venture capitalists and commercial technology companies; second, offering the Department compelling examples of accessing technology by articulating capability needs rather than more traditional requirements-driven acquisition processes; and third, and most importantly, developing the Commercial Solutions Opening award mechanism, a streamlined procurement process that allows the Department to work at the speed of business.

Moving in days and weeks rather than months and years is a necessity for the kind of start-up companies and small businesses that are at the frontiers of digital technologies that dominate the world I come from. DIUx has demonstrated a keen understanding of how to navigate that ecosystem. I attribute DIUx's success in these three areas at least as much if not more to their organizational design, culture, and the degree of autonomy afforded their project leaders than to their use of Other Transaction Authorities (OTAs) or waivers. DIUx plays a key part in many of the efforts that the DIB is championing, from the agile software development in the Coalition Air Operations Center (CAOC) to upgrades in major weapons systems such as the F-22 and F-35. The CAOC efforts alone have saved hundreds of millions of dollars in fuel and maintenance costs that can be reprioritized to other key projects.

"Kessel Run" is a project run out of the Air Force Life Cycle Management Center to modernize the Air Operations Center, with DIUx's support, whereby over 70 airmen have recently undergone training through a partnership with a company, Pivotal Labs, to learn software and app development in a genuine agile software development environment. It is DoD's version of a Software Factory. These airmen regularly ship new features every week in an iterative process seen in successful software companies. Kessel Run has already saved vast sums of money that would otherwise have been spent through the traditional acquisition process. Cycle times that may have extended years are accomplished in weeks.

One of the DIB's fundamental observations is that DoD has shockingly few "software people," underscoring the DIB's October 2016 recommendation to make computer science a core competency. The benefits of applying modern software development techniques are dramatic and efforts such as Kessel Run demonstrate the need for a more software-centric approach to DoD systems. One of the officers leading this effort said, "Our mission here is to turn the Air Force into a software company that provides airpower." I could not agree more.

Other groundbreaking efforts include *Project Maven*, which is the most successful DoD effort to deliver AI to date; the *Joint Improvised-Threat Defeat Organization (JIDO),* which enabled the rapid collection, fusion, and dissemination of operational data by building a classified DevOps-enabled cloud computing environment; the *Defense Digital Service (DDS)*, which brings in the nation's top technical talent to work on problems of significant impact where technology fails the mission of national defense.

I am also pleased to see each Service has undertaken promising efforts which, while still nascent, suggest that senior leaders have a deepening appreciation of the innovation challenges each is facing and are taking steps to introduce and apply new approaches. For the Air Force, I applaud the establishment of *AFWERX*, the launch of *Squadron Innovation Funds*, the appointment of a *Chief Data Officer*, and an emergent focus on talent management and unleashing a culture of innovation among airmen; for the Navy, the establishment of the *Digital Warfare Office* and the application of entrepreneurial principles in the form of ICORPS – imported from the National Science Foundation and the Lean Startup movement -- by the *Office of Naval Research*; for the Marine Corps, the establishment of an *Deputy Commandant for Information* to align and focus information management and digital initiatives, as well as superb work on automating logistics in a program called *NexLog*; and for the Army, the launch of *Futures Command*, which while in its early stages reveals a sense of urgency to consolidate decision-making into a more coherent and compact team.

Barriers to Scaling Innovation Efforts

DoD needs to recognize and reward innovation to ensure that the Department has the right tools, capabilities, and approaches. Yet, the innovations I mentioned above were largely developed outside of the mainstream DoD processes for developing and fielding capabilities. Today, innovators in DoD understand this strategic imperative, which explains their use of alternative pathways and acceptance of calculated risks. Owning this risk requires a level of collective understanding, and even courage, that seems to elude larger Industrial-Age, process-centric approaches. DoD needs to change processes to make these sorts of results the norm, rather than the exception.

There is no single approach to reform – the Department must manage a spectrum of capabilities from Industrial-era aircraft carriers to Internet-era software platforms – but DoD's new normal should include improved approaches to risk, accelerated timelines, and openness to venture innovations. There are a number of structural barriers impeding such a transition:

<u>Software vs. hardware acquisition</u>

The DIB is supporting the Secretary on the study of streamlining the Department's software development and acquisition regulations, as directed in the fiscal year 2018 National Defense Authorization Act (NDAA), to include procurement of software for weapons and business systems, and organizational, behavioral, and cultural barriers to the use of modern software practices. The final report is due next year, and I know the DIB looks forward to sharing its findings with the Department and Congress.

For decades, U.S. military hardware has been the envy of militaries everywhere, and in many cases, still is. However, as we move further into the Information Age, hardware will become commodified, as it has in the computer industry. Competitive advantage is increasingly derived from the power of software and data.

These algorithms, built by AI and machine learning from massive datasets, should be developed through agile software development methods, which must become the norm in DoD. The hardware is simply the delivery system for the software, but it is the software that matters. Yet DoD's current acquisition posture is designed for hardware, as is the budget processes that support it. Failing to address the underlying reasons why so many DoD technology programs run years behind schedule and hundreds of millions of dollars over budget will allow our strategic competitors to catch up in areas where the U.S. is still dominant, and surpass us in emerging areas where the U.S. do not have the same head start. As long as the Department remains organized for hardware acquisition and relegates software to an afterthought, DoD is bleeding out its own advantage.

Based on my personal observations, I see ten core principles that should inform how DoD leaders think about what constitutes effective, modern software development:

1. DoD personnel -- and especially developers -- need access to abundant computing, storage, and bandwidth

2. All software projects should start small, be iterative, and build on success or be canceled

3. Software is never done; budgets should be constructed to support the full life-cycle cost of the software, anticipating that it must be continually upgraded

4. Adopt a DevOps culture for software systems where actual users are placed at the heart of the process and the measure of success is "customer adoption"

5. Automate testing, validation, and certification of software to accelerate critical updates; testing should be concurrent with development, not in long sequential stages

6. Every purpose-built DoD software system should include source code as a deliverable

7. Software is local; every DoD system that includes software should have a local team of DoD software experts who are capable of modifying or extending the software through source code or API access

8. Only run operating systems that are receiving (and utilizing) regular security updates for newly discovered security vulnerabilities

9. Secure data at rest and in transit; data should always be encrypted unless it is part of an active computation

10. All data generated by DoD systems - in development and deployment - should be stored, mined, and made available for machine learning

I've found genuine software engineering a rare occurrence in the Department – with some exceptions such as DDS, Kessel Run, and JIDO, as described above – because DoD has not fully grasped that software decays in place. Unlike hardware, which can be maintained and does not require constant upgrades, software must be upgraded constantly and is usually outdated within two years. This explains the failure of many DoD software programs – costs spiral due to the need for legacy system support, while the software is rife with cyber vulnerabilities. When software fails, the cost to fix it can run in the tens or hundreds of millions, and even then it may ship with reduced capability.

Initiatives like Kessel Run are not only enabling DoD personnel to write an application via agile software development -- as opposed to the more rigid waterfall development that most of DoD employs -- but the Air Force is also training its airmen to do software engineering. In this case, the Air Force has access to its own code, does not have to rely on third party programmers, and can rely on an organic force to tackle challenges the way DDS software engineers do.

Color of money

The current budget and appropriations process was built to address Industrial Age challenges. Software cannot be effectively acquired and employed in such a linear fashion. Poorly-designed major software systems that unnecessarily run millions of dollars over budget point to a need for strong congressional oversight of DoD, but the Congress should also acknowledge that the current inflexible "color of money" system compounds DoD's software challenges.
To capitalize on the potential of software, the Department needs to move quickly when fielding the latest upgrades as well as when testing and operationalizing emerging software solutions. This requires deftly shifting from one color of money to another (and potentially back again) in a matter of weeks or months, not over multiple fiscal years. This could be done in such a way to ensure transparency and accountability, but new paradigms are needed.

Beyond colors of money, OTAs and similar flexibilities can help DoD pursue these kinds of initiatives; however, I have found that too many people in the Department are unaware of these authorities, do not prioritize them, or fail to incentivize program managers and others to use them. As one way to remedy this, DoD should track and encourage the use of such waiver authority.

Cloud

Any military that fails to pursue enterprise-wide cloud computing isn't serious about winning future conflicts. AI is not achievable without modern commercial cloud computing that can store and secure the data DoD regularly collects. This volume of data will only increase in the years to come as the use of sensors proliferates and DoD's ability to collect data expands – while its ability to process it deteriorates due to a reliance on outdated data centers with

limited data storage and transport capacity. This urgent need to address DoD's lack of compute and storage was the focus of one of the Board's official recommendations announced in October 2016.

Fortunately, in recent years, a number of DoD organizations have shifted or begun to shift to the cloud, culminating most recently with the Department's decision to adopt the cloud across the Department. While the Services and other DoD organizations pursuing cloud solutions should be commended, the enterprise-level decision is an important step for the entire Department. Moving to cloud services at an enterprise level will ensure that AI efforts have a common foundation as opposed to operating in silos, which is the DoD norm. A common infrastructure allows many AI projects to grow relatively quickly in an iterative learning environment and for less cost than currently constructed.

Artificial Intelligence

The significance of AI is akin to the first and second offsets that took advantage of nuclear weapons and precision munitions and stealth technology, respectively, to ensure American military supremacy. AI has the power to affect every corner of DoD, from personnel and logistics to acquisition and multi-domain operations; and to create and sustain the asymmetric advantage required to outpace our adversaries. In the long run, AI will profoundly affect military strategy in the 21st century.

DoD has yet to embrace the transformational capabilities of AI. In this space, the Department is neither keeping pace with private industry or academia, nor effectively incorporating or guiding breakthroughs for defense. Deeper focus, closer collaboration, more resources, and a sense of urgency are needed to solve problems of significance to the U.S. and our allies.

Apart from a few excellent examples, most of the Department's work in AI is in basic research, which has been foundational to the development of the technology but is typically not immediately delivered to the warfighter because of the infamous "Valley of Death" in the DoD acquisition environment. From an acquisition perspective, there are no shortcuts to AI. The Department collects large quantities of data, but takes few steps to label, structure, and process them. Though labeled data is the fuel for AI, DoD has yet to fully leverage the value of both unclassified and classified datasets. Data must be collected and then stored and secured in the cloud, at which point the Department can use agile development techniques to train AI systems. Data, therefore, must be viewed as a strategic asset.

The world's most prominent AI companies focus on gathering the data on which to train AI and the human capital to support and execute AI operations. If DoD is to become "AI-ready," it must continue down the pathway that Project Maven paved and create a foundation for similar projects to flourish, in addition to its basic research efforts.

Because this is more of an organizational than a technical problem, 18 months ago the Board proposed establishing a DoD AI Center that would centralize AI coordination and provide enterprise expertise and enablers to Services and the Office of the Secretary of Defense (OSD).

Simultaneously, this center would encourage decentralized execution of AI projects, led by the Services, and the insertion of AI capabilities into existing programs of record. This could be done without disrupting the excellent work of the Service labs, DARPA, and other DoD research organizations upstream by focusing on solving operational problems with existing commercially available technology that requires modest adaptation to military use cases. Without some type of unified, broad adoption of an AI foundation for the entire Department, DoD will soon reach a tipping point after which it will be unable to catch up to its competitors.

I cannot emphasize enough how competitive this field is today, internationally and economically, or how consequential. It is imperative the Department focus energy and attention on taking action now to ensure these technologies are developed by the U.S. military in an appropriate, ethical, and responsible framework.

People and talent

The U.S. military is home to some of the most intelligent, resourceful, creative people I have ever met. Unfortunately, service members have to innovate to work around the barriers that the DoD bureaucracy or poorly designed systems impose on them. I have heard too many stories of entrepreneurial soldiers, sailors, airmen, and Marines who have left the military because their good ideas are regularly ignored or stifled, particularly because these ideas deviate from the norm. This environment generates little motivation to change behavior and undermines the culture of innovation that I believe is widespread in DoD. Unfortunately, this culture is usually thwarted by labyrinthine and unnecessary red tape.

I know that DoD leaders are aware of these challenges. They too are struggling to make sense of a bureaucracy that does not always respond to good ideas unless one is able to survive a gauntlet of complex decision-making processes. And even then, change is not guaranteed.

As one example, I'd like to go back to Kessel Run. This is one of the most promising initiatives in the Department. But the vast majority of participating airmen are using temporary duty assignments to undergo software engineering training. These airmen apply it to real and urgent Air Force challenges and are having a tangible impact in terms of time and money saved. Kessel Run is itself a workaround to a culture and personnel system that does not produce indigenous software engineers. For instance, the initiative lacks permanent billets. Air Force leadership understands this problem well and is seeking a way forward. The alternatives they devise should be closely examined and supported by the Department. This anecdote is but a microcosm of the Department's broader challenge of conducting effective talent management in the digital age.

DoD is fortunate that innovative ideas are breaking through the bureaucracy, but they do so in spite of DoD, not because of it. Along the way, many of these ideas were nearly terminated at multiple stages. It should not be this hard to do the right thing. A fundamental change in recruiting, education, operations, and culture is necessary for the Department to maintain superiority in a technology-driven world. This includes, but is certainly not limited to, an understanding throughout the ranks of how to solve problems using AI, a culture of moving

faster and experimenting with data and software, and the will and imagination to see beyond current workflows and discover future concepts of operation that create advantage over adversaries. It also may require moving the software side of DoD from a hierarchical structure to a meritocracy, arming the Department with ways to match a service member's capability and talent with the requisite authority, responsibility and compensation.

Based on my experience and the hundreds of meetings and site visits with the DIB, government salaries are less a barrier to recruiting and retaining talented service members than is the Department's lack of digital infrastructure these people are used to working with. A lack of comprehensive data access capability, commercial cloud computing, agile software development environment, and a common machine learning platform is holding the Department back technologically. More importantly, it is keeping away top talent that would otherwise be interested in working on DoD's unique problem sets. I have no doubt that top software engineers and data scientists will take a year or two out of their careers to work in DoD. They may not spend more time than that, but DDS's model is viable proof of concept. It is exciting to imagine a future state where DoD's digital infrastructure attracts DDS-level talent across the entire defense enterprise.

Rapid organizations

DoD has attempted to address its structural innovation flaws by establishing organizations that are meant to move fast. Some follow the model of the Air Force's Rapid Capabilities Office, the first Service to establish such a group. They all now have an RCO or equivalent office, which complement the activities of DIUx. For example, the Strategic Capabilities Office takes existing platforms and capabilities in DoD and repurposes them for different but critical missions, such as the Navy's Standard Missile-6, which was refashioned from a solely defensive weapon into an offensive asset designed to attack enemy ships. Conversely, as you well know, DARPA finds new technologies for the future fight via longer timelines and research that examines the viability of certain technologies. Each of the rapid organizations has a distinct yet complementary responsibility in making the U.S. the predominant technological force - today and in the future.

At their onset, these rapid organizations were placed outside the usual hierarchy, to establish autonomy and facilitate results, but the ultimate goal must be to incorporate their practices into the broader acquisition system. The Department is not at that point yet, but the mindset of adopting innovative best practices as the norm rather than the exception is the correct one.

In an organization as large as DoD, good ideas that cannot scale would seem to have limited utility. Scaling innovation is crucial, but it is also important to create pathways for new ideas and environments that can nurture different approaches and contrary views. You need both – they are optimized for different variables. Organizations optimized for consistency, reliability, and stability produce value, but not ingenuity or innovation. That requires a different culture, rules, and organizational design, and often different people. This is the reason why innovative organizations often must be started separately, managed differently, and protected from bureaucracy. This is true in industry as well as government. When considering the mechanisms

for scaling innovation, DoD leaders – and their congressional overseers – should be mindful of balancing these competing priorities.

Conclusion

In my opinion, the Board's efforts and recommendations to date dovetail with the recently-published National Defense Strategy, which correctly captures the dynamics of technological competition ("Success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts its way of fighting") and introduces new operational concepts that could widen the competitive space ("foster a culture of experimentation and calculated risk-taking"). DoD leaders understand the need to adapt to new security realities, and countering institutional inertia will be challenging, but after nearly three-quarters of a century of U.S. strategic and technological dominance, the status quo will only guarantee a loss of superiority on the future battlefield. Change is more important than ever before.

I believe Congress can play an important role in influencing the Department's culture of innovation. Alongside other Board members, I have heard many times from leaders and personnel at all levels whose fear of congressional censure was a major contributing factor to their slavish adherence to process and reluctance to try new approaches or take calculated risks. At the same time, in interactions with Congress, I am heartened to hear many of the same frustrations and criticisms of the Department that DoD leaders make themselves. There is common ground here. This committee has helped enact significant acquisition and personnel reforms over the past few years and I invite the committee members here today to devote some time to this question of how to further partner with DoD to balance the need for oversight, transparency, and accountability for taxpayer resources with the reality that DoD must adopt a more entrepreneurial mindset, or risk a potentially devastating loss of competitive advantage over time.

I hope I've shed light on the path forward, what this change might look like, and how to get there. There are no shortcuts on this path. The Department must overcome significant obstacles in its culture, talent management, and processes, to name a few. I am not alone in these assessments and hope this hearing serves as a call to action for everyone concerned. Thank you and I look forward to your questions.

Dr. Eric Schmidt
Technical Advisor, Alphabet, Inc

Eric Schmidt is the technical advisor to the board of Alphabet where he was formerly the executive chairman. As executive chairman, he was responsible for the external matters of all of the holding company's businesses, including Google Inc., advising their CEOs and leadership on business and policy issues.

Prior to the establishment of Alphabet, Eric was the chairman of Google Inc. for four years. From 2001-2011, Eric served as Google's chief executive officer, overseeing the company's technical and business strategy alongside founders Sergey Brin and Larry Page. Under his leadership, Google dramatically scaled its infrastructure and diversified its product offerings while maintaining a strong culture of innovation, growing from a Silicon Valley startup to a global leader in technology.

Prior to joining Google, Eric was the chairman and CEO of Novell and chief technology officer at Sun Microsystems, Inc. Previously, he served on the research staff at Xerox Palo Alto Research Center (PARC), Bell Laboratories and Zilog. He holds a bachelor's degree in electrical engineering from Princeton University as well as a master's degree and Ph.D. in computer science from the University of California, Berkeley.

QUESTIONS SUBMITTED BY MEMBERS POST HEARING

April 17, 2018

QUESTIONS SUBMITTED BY MRS. DAVIS

Mrs. DAVIS. In your view, would Congress be better able to engage with important defense issues if it had access to comprehensive and forward-looking technology assessments?

Secretary GRIFFIN. Yes, I believe that, in order to make informed decisions in this arena, the R&E enterprise should maintain open and thorough communications with Congress regarding the path forward for not only emerging technologies, but also emerging threats that drive our technical priorities. It is easier to understand the gravity of these challenges with comprehensive technology assessments that are both qualitative and quantitative in nature. In addition, technology assessments that are specific to existing and emerging priority areas such as hypersonics and directed energy can help scope the support needed from Congress, and ensure a common understanding of the most critical defense issues.

Mrs. DAVIS. On which defense issues would it be helpful for Members of Congress to have comprehensive and forward-looking technology assessments?

Secretary GRIFFIN. Missile defense, space, nuclear modernization, hypersonics, directed energy, artificial intelligence, cybersecurity, quantum science, microelectronics, and fully networked command, control, and communications are all areas of needed technological advancement. These areas also require an understanding of the international competitive landscape at present and in the future to maintain a military edge. The Department and Congress would benefit greatly from an understanding of the future direction of technologies supporting these different areas as well as the Department's plans to mitigate any challenges to technological superiority in these areas.

Mrs. DAVIS. How would you expect the OTA would be able to inform Congress' conversations on defense technologies?

Secretary GRIFFIN. I believe the DOD should continue to pursue collaboration with commercial entities using streamlined mechanisms such as Other Transaction Authority (OTA) to assess, evaluate and capitalize on the potential of new technologies and capabilities in order to provide a cost-effective warfighting advantage. We must continue to utilize non-traditional mechanisms to accelerate development and, ultimately, to deliver technologies more quickly and efficiently to the warfighter in the field. The OTA is a powerful tool, and I believe, when used properly, it is an important model for Congress to consider in the emerging conversation of current and future acquisition reform.

QUESTIONS SUBMITTED BY MR. GALLAGHER

Mr. GALLAGHER. When it comes to funding defense-relevant innovation, the private sector plays a key role—but market incentives aren't always aligned with defense interests. When it comes to defense innovation, U.S. venture capital often tends to focus on software, not hardware, given shorter return horizons and lower capital barriers. What, if any, concerns do you have about "hard," non-software technologies being underfunded?

Given the past success of organizations like In-Q-Tel, could a U.S. government-supported investment vehicle, focused on the non-software technologies in greatest demand to military leaders with the highest potential impact from investment, be of use to better capture innovation and leverage it in support of DOD objectives?

Secretary GRIFFIN. In-Q-Tel has been a valuable asset for the communities it serves, particularly with regards to leveraging American venture capital efforts in ways that provide critical innovation to the warfighter while allowing those private businesses to maintain their non-DOD business and products. I would support exploring options for DOD to partner with venture capital firms and investors to leverage hardware and software alike in a way that is beneficial to all parties. One challenge facing the Department and the Nation is that hardware vice software technology development underpins some of the desired defense capabilities. The longer time horizons (8–12 years) associated with hardware development provide challenges to some innovation funding mechanisms in use today such as venture capital funding. For example, the percentage of venture capital funding invested in software

rose from 55% in 2006 to 92% in 2017. Anecdotally, this trend may be changing but the data is not yet compiled to verify this. I am exploring multiple approaches to address appropriate hardware technology development in partnership with private industry. The Microelectronics Initiative for National Security and Economic Competiveness is one example of an effort that is investing in creating state of the art hardware technology for the next generation of DOD capability. 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 am committed to pursuing opportunities to fully leverage partnerships with venture capital and industry that apply the nation's best expertise, creativity and innovation to advance our technology and improve our edge in warfare.

Mr. GALLAGHER. When it comes to funding defense-relevant innovation, the private sector plays a key role—but market incentives aren't always aligned with defense interests. When it comes to defense innovation, U.S. venture capital often tends to focus on software, not hardware, given shorter return horizons and lower capital barriers. What, if any, concerns do you have about "hard," non-software technologies being underfunded?

Given the past success of organizations like In-Q-Tel, could a U.S. government-supported investment vehicle, focused on the non-software technologies in greatest demand to military leaders with the highest potential impact from investment, be of use to better capture innovation and leverage it in support of DOD objectives?

Dr. SCHMIDT. I am concerned that key non-software technologies important to the Department of Defense are being underfunded. With the U.S. venture capital community focused primarily on software, due to the market incentives you reference, China is aiming to replace the U.S. as the global leader in these technologies, such as supercomputing, batteries and microelectronics, drone swarms, and more. This is concerning not only because it is important for the U.S. to maintain its technological edge over all adversaries, but also because if these technologies come to be dominated by China, their supply chain that leads to U.S. usage could become compromised, putting the U.S. in a permanently-precarious position. I believe an investment vehicle focused on non-software technologies could be one of numerous ways to address the funding gap in this area.

QUESTIONS SUBMITTED BY MR. BROWN

Mr. BROWN. Considering the framework of the "three P's" for innovation culture—Proximity, how to properly position common areas and shared resources to encourage collaborative problem solving; Privacy, how to create spaces that facilitate private conversations and help people control interactions; and Permissions, how to encourage informal interactions with staff from different backgrounds and with different perspectives.

Secretary Griffin, how is the Department releasing the innovation potential of its people?

Secretary GRIFFIN. The Department strives to foster an innovation culture by protecting stable science and technology funding, pursuing technical talent with a drive for innovation, encouraging creativity and appropriate risk taking, and recognizing and rewarding results achieved through innovation. We must prepare for an uncertain future with rapidly evolving and adaptive threats with innovative and disruptive technologies and the continued pursuit of opportunities for change. The Department has located several offices in proximity to major innovation hubs around the country to enable collaborative research and shared resources for efficiency. These offices include the Army Research Laboratory open campus offices in Adelphi, Maryland, Southern California, Austin, Texas, and Boston, Massachusetts as well as the Defense Innovation Unit Experimental (DIUx) in Silicon Valley. Additionally, we protect our most innovative concepts and facilitate collaborative work in controlled areas through our joint program offices and tri-service projects in high-visibility technologies. By leveraging the communities of interest and conducting outreach activities to industry and academia, the Department's top technical talent is empowered to interact with staff that have a range of backgrounds, expertise, and perspectives. Ultimately, the Department must be able to drive its military innovation cycle faster than any adversary to sustain technological superiority. Our competitors are closing the gap because of our processes, not our talent. The Department's research and engineering enterprise is committed to working with our partners across the DOD to ensure our workforce will leverage the full range of authorities granted from Congress to enable innovative business practices. In addition, the research and engineering enterprise will focus on engaging non-traditional partners in shaping

our processes, technical focus/roadmaps, and understanding our comparative advantage.

QUESTIONS SUBMITTED BY MR. BANKS

Mr. BANKS. NSWC Crane has been successful at fostering the development of a robust and rapidly expanding innovation ecosystem. This nationally recognized model of regional collaboration has propelled NSWC Crane along with its partners to the forefront of technology development through its utilization of resources from industry, academia, and the public sector. This partnership has embarked on solving some of nation's toughest problems such as (but not limited to) trusted/assured microelectronics, hypersonic and artificial intelligence/machine learning.

The Navy serves as the DOD's Executive Agent (EA) for Printed Circuit Board (PrCB) and Interconnect Technology which has the responsibility to ensure the DOD has trusted access to those technologies. From circuit cards to the microelectronics that populate them. Our DOD must have "trusted assemblies" to complete their mission.

Dr. Griffin, Do you support an active oversight role in partnership with OSD within the Trusted and Assured Microelectronics Efforts/Microelectronics Innovation for National Security and Economic Competitiveness (MINSEC) to fulfill the congressional mandate for DOD's EA to ensure the DOD has trusted access to those technologies?

Secretary GRIFFIN. One of my top priorities as Undersecretary of Research and Engineering is Microelectronics, which includes ensuring access to Trusted and Assured Microelectronics. As you recognize, NSWC Crane is an integral partner in this collaborative effort and provides important leadership and capabilities to achieve this priority. NSWC Crane specifically has a number of lead roles in Trusted and Assured Microelectronics, the Joint Federated Assurance Centers (JFAC), and Strategic Radiation Hardened Materials and Printed Circuit Boards (PrCB). We see them as a critical partner in the Microelectronics Innovation for National Security and Economic Competitiveness (MINSEC).

Mr. BANKS. NSWC Crane was major contributor to OSD and Strategic Systems Program's (SSP) recent successful FE1 Conventional Prompt Strike Flight Test. NSWC Crane exercised their innovation eco system to reach out to their university and industry partners to provide rapid solutions. As the program transition from OSD to the Navy, NSWC Crane role will grow and the innovation ecosystem will continue to be leveraged. Dr. Griffin, as the Undersecretary for Defense Research and Engineering, how can you work with the labs to ensure they have resources, authorities and facilities to execute their mission?

Secretary GRIFFIN. Strong and stable resources, along with existing authorities, greatly enhance the laboratories' abilities to operate more efficiently and effectively. Therefore, I will continue to advocate for and support proper resourcing for our laboratories and work to remove institutional barriers that hinder their use of flexible authorities. A severely aging infrastructure presents a significant challenge to our ability to maintain our technological edge over our adversaries. Laboratories must compete against other military construction projects for limited resources and have not fared well in this process. In the past, labs have had to rely on Congressionally-granted authorities, such as Section 219, to largely sustain themselves and make much-needed upgrades through minor military construction funding. It is also vital the Lab Directors have the necessary hiring flexibilities, as well as good lab facilities, to entice a strong workforce. Our scientists and engineers play a prominent role in developing technologies that benefit the Nation as a whole and their subject matter expertise is essential for the Department to meet the needs of the Warfighter.

Mr. BANKS. Dr. Schmidt, how can the EA work closely with the DIB to accelerate solutions to the warfighter?

Dr. SCHMIDT. In my capacity as Chair of the DIB, I've learned of NSWC Crane's important contributions and their unique role as both a research and development facility. The DIB has publicly stated AI's central importance to the Department of Defense, and accordingly, AI is a key area where DIB and Crane can work closely together on developing solutions, including in cybersecurity, logistics, training, communications, and many other critical domains. The DIB stands ready to partner with Crane in these ways.

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