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Subcommittee on Emerging Threats and Capabilities

COMMITTEE ON
ARMED SERVICES

UNITED STATES SENATE

TO RECEIVE TESTIMONY ON SCIENCE AND TECHNOLOGY, TECHNOLOGY MATURATION, AND TECHNOLOGY TRANSITION ACTIVITIES

Wednesday, April 21, 2021

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Wednesday, April 21, 2021

U.S. Senate
Subcommittee on Emerging
Threats and Capabilities
Committee on Armed Services
Washington, D.C.

The committee met, pursuant to notice, at 2:30 p.m. in Room SR-222, Russell Senate Office Building, Hon. Mark Kelly, chairman of the subcommittee, presiding.

Committee Members Present: Kelly [presiding], Shaheen, Kaine, Warren, Peters, Ernst, Fischer, Cramer, Scott, Blackburn, and Tuberville.

OPENING STATEMENT OF HON. MARK KELLY, U.S. SENATOR FROM ARIZONA

Senator Kelly: Good afternoon, everybody. Thank you for joining us today. The Emerging Threats and Capabilities subcommittee meets this afternoon to receive testimony from the leaders of the Department of Defense's Science, Technology, and Innovation Enterprise on how they are working to ensure that the United States retains its technological superiority to support defense and national security missions.

I would like to welcome our witnesses today, Dr. Peter Highnam, Deputy Director of the Defense Advanced Research Projects Agency, DARPA; Major General John George, Commanding General of the Army Combat Capabilities Development Command; Rear Admiral Lorin Selby, Chief of Naval Research; and Brigadier General Heather Pringle, Commander of the Air Force Research Laboratory.

I also want to take the opportunity to thank you all for being here today and for your continued service to the nation, and for your efforts to ensure that we are leveraging innovation to support our servicemembers. As we all know, the United States is in a competition with China in all areas of technology critical to our national security. To date, our technological superiority in areas like advanced combat aircraft, missile technologies,

nuclear, and space technology, and land and naval power have been enough to maintain our advantage, despite the ambitions and population of China.

In my view, it is critical that we maintain our military superiority to continue to show the Chinese government and our competitors that starting a conflict, or challenging us, is not in their best interest. I believe that our technological capability is central to that aim.

While innovation is what we have historically done better than anyone, technological superiority is not a natural right of our nation. It has been earned and developed over decades by the people like our witnesses and their predecessors, who worked to leverage American ingenuity and innovation, people who work to establish partnership between the military, civilian agencies, industry, academia, and international partners to develop and deploy the weapons systems and defense capabilities that we have today. Capabilities ranging from radar to precision weapons to fifth-general fighters to robots on the battlefield all have their roots in the science and technology enterprise that we are discussing today.

It is also important to remember that our national investment in these research programs ultimately benefits not just the Department of Defense but the broader American public as well. As we all know, DoD-supported research is

now used in general society to promote economic growth and advance the nation's health care system and improve overall quality of life, things like the internet, GPS, smartphones, advanced materials, and even medical advances, including some of the vaccines being used to address the COVID pandemic today. These are all products of research programs.

So I hope that in this hearing we can examine how DARPA and the Services are using the resources and authorities they have been given to help us win the global technological competition against adversaries like China. And I hope that the witnesses can address any challenges that they are facing in trying to achieve that goal, and give us insights and recommendations on what this subcommittee can do to best support them.

I will now turn it over to Senator Ernst for any opening comments that she may have.

STATEMENT OF HON. JONI ERNST, U.S. SENATOR FROM IOWA

Senator Ernst: Thank you very much, Chairman Kelly, and congratulations on taking the gavel for Emerging Threats and Capabilities, and I really do look forward to working together on this committee, and I appreciate your leadership in setting up the hearing today.

For many decades, the Department of Defense has driven global research and development to create technologies that have become the backbone of our digital society. And in a more recent example, the vaccine, as Chairman Kelly had noted, and other biomedical research done at the Defense Advanced Research Projects Agency, or DARPA, has enabled the development of the new vaccine techniques currently being used to fight the COVID-19 pandemic.

As a result of these and other important research and development activities, the United States military has enjoyed technological superiority over our adversaries for decades. Unfortunately, our adversaries have learned from our success and are investing heavily in developing and stealing capabilities like artificial intelligence, 5G, hypersonics, emerging biotechnologies, quantum computing, and directed energy.

The fiscal year 2019 National Defense Authorization Act established an independent commission to study the application of artificial intelligence to national security

applications. Their final report, released in March 2021, states, "The United States has neither identified nor prioritized leadership in the technologies that are central to national competitiveness."

In contrast, the commission's report notes that, "China is pursuing a comprehensive technology leadership strategy. China's strategic investments in key sectors through its Made in China 2025 Initiative threaten U.S. technological prowess, economic prosperity, and national security."

The report goes on to note that, "In addition to investments in AI, China is seeking to become a world leader in quantum, 5G, and biotech, among other areas, and sees its strategies to lead in AI and each of these other technologies as mutually reinforcing."

I am concerned we are not keeping up with our competitors, and I am looking forward to hearing our witnesses talk today about the research and development activities in the defense laboratories and at DARPA and each of the Service research organizations to support modernization goals of the National Defense Strategy. What can this subcommittee do to support efforts to maintain this technological superiority of our warfighters?

And thank you very much to our witnesses for appearing in front of this afternoon, and I look forward to your testimony. And with that, Mr. Chair, I yield back.

Senator Kelly: Thank you, and I will now recognize the Deputy Director of DARPA, Dr. Highnam, for 5 minutes.

STATEMENT OF DR. PETER HIGHNAM, DEPUTY DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Mr. Highnam: Thank you. Chairman Kelly, Ranking Member Ernst, and members of the subcommittee, thank you very much for the opportunity to testify today and for the committee's strong support of DARPA over the years. My name is Peter Highnam and I am the Deputy Director of DARPA. It is a pleasure to be here with my colleagues who are representing the critical research and development functions of the United States Navy, Army, and Air Force.

While we work closely with each of these service organizations, DARPA has a unique mission in both the DoD community and the broader U.S. technology ecosystem. That mission is to prevent technological surprise, by making pivotal investments in breakthrough technologies for national security. What that means is we anticipate, create, and demonstrate technologies that are nowhere on technology roadmaps and often outside most people's imaginations.

For over 60 years, in partnership with innovators inside and outside government, DARPA has repeatedly delivered on our mission. We transformed revolutionary concepts and seeming impossibilities into practical capabilities. Examples of those capabilities include stealth technology, position-guided weapons, and unmanned

aerial vehicles, as well as icons of modern society such as the internet, automated voice recognition, and language translation, and GPS receivers small enough to embed in nearly any consumer device.

Technologies like these provide more options for our nation's leaders and the Military Services. Today, with increasingly complex challenges in a rapidly changing world, DARPA's role has never been more vital.

At DARPA, we think not just about scientific and engineering innovation but also about the innovation ecosystem. That ecosystem includes many overlapping and adjacent communities in academia, industry, and partnerships across the Federal Government. It includes everything from fundamental research to global-scale systems of systems. It includes innovation not only in technology but in processes and transition strategies as well. And most importantly, it includes a constantly changing crew of DARPA program managers, who come from and will return to that ecosystem, who seek to solve not just today's problems but tomorrow's as well.

One of the best illustrations of how DARPA is related to the COVID-19 pandemic. About 10 years ago, DARPA began heavy investments in something called mRNA vaccines. mRNA vaccines are nearly a household word today, but at the time they were much more obscure, and DARPA's investments were

based on the insight of individual program managers who anticipated their need for both military and public health missions. The research is now playing a leading and catalytic role in today's fight against COVID-19. In typical DARPA fashion, the agency made significant investments in technology years before it was known to be needed, leading to high-impact capabilities related to prevention, diagnostics, and treatment that have helped to mitigate the current crisis.

From vaccines and diagnostics to defense and offensive hypersonic technologies, state-of-the-art artificial intelligence, quantum information systems, microelectronics, sophisticated cyber solutions, inexpensive space-based capabilities, supply chain robustness and resilience, and much more, DARPA has forged new paths and continues to deliver on our mission. The culture is strong. It persists. You have an agency completely focused on the mission.

I look forward to working with the members of this subcommittee and others in Congress to ensure the security and resilience of our nation. I would be most pleased to answer your questions. Thank you.

[The prepared statement of Mr. Highnam follows:]

Senator Kelly: Thank you, Dr. Highnam. I will now recognize the Commanding General of the Army Combat Capabilities Development Command, General George, for 5 minutes.

STATEMENT OF MAJOR GENERAL JOHN GEORGE, COMMANDING GENERAL, UNITED STATES ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND

General George: Chairman Kelly, Ranking Member Ernst, distinguished members of the committee, thank you for your support and your commitment to the Army's soldiers, families, and our civilians. I appreciate the opportunity to testify alongside my DoD S&T partners, Dr. Highnam, General Pringle, and Admiral Selby.

The mission of the United States Army's Combat Capabilities Development Command, known as DEVCOM, as a part of the larger Army Futures Command, enables the delivery of the Army's modernization priorities through advancing science, technology, and engineering. Futures Command leads the persistent modernization of the Army, and it has created unity of effort to develop and deliver capabilities.

Under the unified leadership of Futures Command, we have evolved the way we characterize our execution of S&T, and we place increased emphasis on ensuring a balance of investment across three areas. First, technology insertion. This is focused on the delivery of S&T in support of today's signature efforts. Second is transformational capabilities, efforts that will likely transform how we will fight in the future operating environment. This is all made possible by the third, foundational research, executed by my Army

Research Lab, which is focused on the realm of the possible, realizing collaboration with our external academic and industry partners.

To inform both transformational capabilities and foundational research, DEVCOM executed Futures Command's technology deep dives in support of the Army's research priorities. Along with our government and academic partners, and hundreds of participants, we have reviewed the Army's technology focus areas in advanced spaces like quantum, hypersonic flight, convergent manufacturing, autonomy, and synthetic biology.

Leveraging this three-part S&T construct and expanding our definition of success beyond just the transition of technology into programs, one initiative under Army's Futures Command that has changed the way that we pursue technologies is our Ignite strategy. This strategy broadens and institutionalizes the impact of S&T by having science shape concepts and technology-informed requirements.

Last year we established the Virtual Enterprise Collaboration Platform with more than 600 partners across 35 Army organizations, and we led more than 20 workshops to inform how and what we will fight with differently in the future. This has brought together people from all four services, 13 partner nations, industry, other government agencies, think tanks, and academic institutions.

As further representation of the change implemented in our S&T mission, the Army is expanding our use of soldier-centered design, taking potential solutions from the lab into the dirt. Routine and brutally honest soldier feedback is incredibly important to make sure we deliver what is needed.

In 2021, we will conduct more than 200 experiments, or what we call soldier touchpoints. We leverage this feedback to inform an agile development process where we are able to modify efforts, re-engineer products, realize cost savings, and cut the time it takes to deliver soldiers' capabilities.

Recognizing that the joint warfighter will need integrated capabilities that operate at machine speed to win on the hyperactive battlefields of the future, in 2020, the Army initiated our premier experimentation event, Project Convergence. This is where we went from concept to experimentation and demonstration in under 8 months. This year, for Project Convergence '21, we will expand participation and focus on joint interoperability with our DoD partners in an INDOPACOM vignette. DEVCOM is working alongside more than 75 industry partners on our technology scheduled to be in this year's event.

To support Project Convergence, we have recently stood up the Joint Systems Integration Lab, or the JSIL, where, on 8 April, we hosted all three Service chiefs. The JSIL

provides lab-based risk reduction, and ultimately will enable Joint All Domain Command and Control, or JADC2.

All this is only possible with a continued emphasis on talent management and the future of work. We continue to explore new ways to attract and retain talent that we need to remain effective and competitive, and to do so we are leveraging our existing network. DEVCOM has regional research hubs, co-located with our strategic partners across the nation, centered in regions with existing innovation networks like Boston, Playa Vista, Chicago, and Austin. Our hubs are positioned to tap into talent where it resides and are tightly linked with outreach and diversity initiatives to work towards our goal of an expert S&T workforce.

So in closing, we are optimistic about our ability to shape the future. The authorities that Congress has provided us enhance our ability to enable our world-class talent, pursue lab revitalization, and acquire information technology necessary for the Army's multidomain transformation.

So thank you for your time and I look forward to answering your questions.

[The prepared statement of General George follows:]

Senator Kelly: Thank you, General. And Admiral Selby, the Chief of Naval Research, is recognized for any opening remarks.

STATEMENT OF REAR ADMIRAL LORIN SELBY, CHIEF, NAVAL RESEARCH

Admiral Selby: Good afternoon, Chairman Kelly, Ranking Member Ernst, and distinguished members of the committee. I thank you for inviting me and my colleagues to be with you today to talk about what I think is actually a critical topic at this time.

From a science and technology standpoint, we are clearly at an inflection point in history. As you are well aware, for the first time in several decades we are facing a near-peer competitor who is basically set on trying to displace us as the world's superpower. We are truly in a race for technological superiority. For 75 years, the Navy and Marine Corps leadership has looked to the Office of Naval Research to maintain that technological advantage and ensure that our sailors and Marines are never in a fair fight.

Today, more than ever, technology shapes the battlefield, whether it be on land, in the air, on or under the sea, or in cyberspace, which is why it is absolutely critical that we maintain a technological edge.

Having served in the role of Chief of Naval Research now for just under a year, I am focusing the Naval Research Enterprise, or NRE, on four distinct areas to do just that: people, products, processes, and partnerships. The NRE,

which consists of the Office of Naval Research, the Naval Research Laboratory, ONR Global, and PMR 51, has an amazing workforce of nearly 4,000 dedicated scientists, engineers, contracts, legal, and financial specialists, and military members. Like everyone, my workforce was affected over the past year by the COVID-19 pandemic, and I would like to publicly thank them for their inspiring flexibility and commitment to their work.

As we look to the world after COVID, I am looking to focus the workforce on modernizing the NRE talent management system through diversity, employee satisfaction, and succession planning. Central to this effort is my firm commitment to increasing awareness of the naval science, technology, engineering, and mathematics, or STEM, programs, particularly to improve engagements with our historically black colleges and universities and minority-serving institutions. The shortage of people interested in STEM careers today is a matter of national security, and the next generation of STEM professionals who will lead America needs to reflect American society. Quite simply, we have to get out kids from all locations and demographics interested in STEM today or we will be unprepared as a nation to face the challenges of tomorrow.

To remain relevant, the NRE must continue to provide capabilities to the fleet and Marine forces. Recently, we

have had success in delivering capabilities in directed energy, unmanned systems, artificial intelligence and machine learning, electromagnetic warfare, and autonomy. Specific examples, among many game-changing capabilities emerging for our fleet and Marine forces include the solid-state laser, technology maturation prototype, which is installed on USS Portland, as well as the delivery of Sea Hawk and Sea Hunter unmanned surface vessels.

In many cases, the successes we have in providing products today is the direct result of early-stage research conducted 10 or 20 years ago. As a sole dedicated naval investor in basic research, ONR will continue to sponsor nascent research in areas such as artificial intelligence, digital engineering, quantum computing, biotechnology, advanced manufacturing, long-range precision fires, expeditionary energy, and undersea warfare.

Yes, I also recognize that unlike many years ago the preponderance of technology investment today comes from the private sector and not from the government. Through our manufacturing technology and Small Business Innovation Research efforts, they continue to consistently be successful. We also need to look to new avenues for engaging across the spectrum of industry to ensure we are penetration with the private sector to the best ideas. For this reason, I view NavalX and Tech Bridges as absolutely

critical capabilities for connecting the Navy and Marine Corps across the innovation pipeline.

Similarly, within ONR, we need to continue to deliver near-term solutions to emerging fleet and Marine Corps requirements, specifically in areas of experimentation. For example, the Marine Corps just completed the Naval Integration in Contested Environments Advanced Naval Technology experiment, where several ONR technologies were demonstrated in an operationally relevant environment at Camp Lejeune a couple of weeks ago. Also, at this very moment, ONR and the fleet are evaluating some 30 new technologies as part of an Integrated Battle Problem 21 exercise off the coast of Southern California. By providing our warfighters with opportunity to employ novel technologies, we provide them with the opportunity to give direct feedback to the developers and to begin to develop appropriate concepts and doctrine.

From a partnership perspective, I am happy to say, on the domestic front, with the organizations around this table and others across DoD and government, we are completely aligned an in sync. Internationally, as I am dual-hatted as the Chief of Naval Research and the Senior National Naval Representative, I am committed to ensuring that our international allies continue to see the United States as the partner of choice for research development investments.

Today, over two-thirds of global R&D investment are outside the United States, making it absolutely critical that we maintain awareness of the state of research for both partners and potential adversaries alike.

Fortunately, the small and agile ONR global team is equipped to do just that, through discovering emerging research around the world, helping potential partners navigate the complex U.S. R&D ecosystem, and promoting transparency and building trust.

Again, it is an honor to be here today, and I look forward to your questions.

[The prepared statement of Admiral Selby follows:]

Senator Kelly: Thank you, Admiral. And now General Pringle, the Commander of the Air Force Research Laboratory, will be recognized for opening remarks.

STATEMENT OF BRIGADIER GENERAL HEATHER PRINGLE, COMMANDER, AIR FORCE RESEARCH LABORATORY

General Pringle: Chairman Kelly, Ranking Member Ernst, and distinguished members of the subcommittee, thank you for this opportunity to provide testimony. I am honored here to join my colleagues here today.

The Department of the Air Force has a comprehensive technology portfolio, deep scientists and engineer bench, and world-class facilities that accelerate development of innovative technologies for airmen and guardians. I am more than confident in our team, but nonetheless, we remain clear-eyed about the challenges ahead.

With the complexity of an evolving landscape, as we have described here today, the Air Force Research Lab remains united as one lab supporting two services, both the Air Force and the Space Force, as we address these challenges.

I would like to start by highlight our substantial efforts to support the nation's response to COVID-19, which ensured the timely increase in domestic production of personal protective equipment and mitigated damage to the defense industrial base. Numerous researchers responded to the call by evaluating decontamination technologies for the Air Force fleet, building computational models to support commanders, and designing new transport systems for air-

evacuated COVID patients.

Even while responding to COVID, our S&T community never ceased in their efforts to develop transformational capabilities in line with our 2030 strategy. In fact, AFRL established a new Transformation Capabilities Office to develop a pipeline of multidisciplinary programs that aim to grow into game-changing capabilities called Vanguards. Vanguards represent a new model for accelerating the transition of S&T successes across the valley of death, and we look forward to results from these Vanguards in the near future.

Still more opportunities exist in the space domain. Though we have long recognized the importance of space superiority, AFRL has taken new steps to demonstrate its commitment to both the Air Force and Space Force as independent services. As always, we will continue to encourage problem-solving across multiple domains, multiple disciplines, and actively develop cross-cutting solutions.

The commercial space sector has also energized a number of public-private partnerships and CRADAs with companies looking to use our facilities and leverage our expertise, resulting in mutually beneficial endeavors.

In fiscal year 2021, AFRL strengthened its partnerships by standing up a new Strategic Partnering Office, as well as bolstering our relationship with nontraditional companies.

Leading in this area, AFWERX awarded contracts worth over $700 million to 1,400 small businesses, with over 75 percent of the recipients being new partners to the DAF. We are excited to access so many new sources of innovation.

To better leverage extramural research advancements, our team works closely with academic institutions across the nation to shape our research and grow a larger, highly talented pool of U.S. citizens skilled in tech areas we need. Altogether, these robust networks of partnerships, which include 23 international allies, NATO, and Five Eyes partners bring a wealth of knowledge and domain-specific expertise to ensure we stay on the cutting edge of research.

To build the best team, AFRL developed a new approach to human capital that incorporates industry best practices and seamlessly integrates the human capital lifecycle. We greatly appreciate the numerous authorities that Congress has provided to recruit, hire, and retain top talent. In particular, the Direct Hire Authority enabled the use of executive headhunter firms for hard-to-fill positions, such as the enhanced pay authority, which we have fully employed.

Every day we seek opportunities to achieve future operational dominance through investment in relevant scientific areas such as artificial intelligence, autonomy, biotech, cyber, quantum, direct energy, microelectronics, and hypersonics. Horizon scanning enables us to invest in

ways that avoid duplication and build complementary efforts with our sister services, DARPA, and others.

Despite COVID-19, we had an exceptional year responding to both emergent and enduring technology needs, while pushing the leading edge of science. I would be happy to provide more details.

Above all, we have a workforce that is truly special, driven by a tireless devotion to learning difficult specialties, and applying expertise and creativity to novel problems. Thank you for your strong support of the Air Force and Space Force S&T, the authorities that you have provided, and this opportunity to testify.

[The prepared statement of General Pringle follows:]

Senator Kelly: Thank you, General, and thank you to everyone for your testimony.

So before we begin questions, let me remind everybody how we are going to proceed here with the remote participants. We do have some. I want to let everyone know how things are going to run.

So since this is impossible to know exactly when our colleagues who be joining remotely arrive, we are not going to be following what is called the standard early bird timing rule. Instead, we will handle the order of questions by seniority, alternating sides until we have gone through everyone. And once we reach the end, if there is anybody that is missed we will go back and start at the top again until everybody has had a turn.

With that, I am going to begin our 5-minute round of questions. So this is for all the witnesses, and I want to talk about semiconductors for a moment. In last year's NDAA, we authorized the Chips for America Act, and I am currently working with colleagues to ensure we can provide the funding necessary to address current supply chain vulnerabilities.

Can you speak to why semiconductors and microelectronics are important for our weapons systems and for our national security?

General George: Chairman, thank you for the question.

I will start the team down here. So first of all, semiconductors are in nearly every piece of kit that we field to our soldiers in our formations, and, you know, we have part of our command that looks at the integrity and the vulnerabilities of semiconductors, as a part of the systems that we field. We certainly recognize that the supply chain is at risk and that we have got to be very careful to know the origin of the semiconductors that are going into our critical capabilities. Especially as we get into things like AI and machine learning, the speed of our systems and the decision algorithms that we use have got to be reliable and have got to move fast.

Admiral Selby: I will just continue that. So clearly semiconductors are in all of our, you know, microelectronics for our radar systems, our communications systems, our high-performance computing systems, for AI, and all the things we are trying to do. As you are all well aware, the majority of that has been offshored over the last several decades, so it is a critical concern that there is obviously a vulnerability there for the supply chain as well as potential vulnerabilities for other aspects of what could be done to the electronics when it is offshore.

So I think we are all working together to try to combat that, to come up with strategies, but the things the Hill has done over the years to help us with that is going to be

critical to making this effective.

Senator Kelly: Do any of the labs help manufacturers or help develop technology that could help a U.S. company, let's say Intel, lead to developing, let's say, a five-nanometer chip or even beyond that, 3 or 1 nanometer? I mean, there is a path to get there. Do any of the labs work specifically in developing that technology?

Admiral Selby: I think we all are. Naval Research Lab, for instance, is doing a lot of work now. But just historically, gallium nitride, what is in your phone and your flat-screen TV, was technology developed with others but Naval Research Lab played a pivotal role in that, and the Naval Research Lab today is doing additional work on future concepts. So yes, sir.

General George: And the Army Research Lab is also looking at the materials as a part of the conductor business.

Senator Kelly: General Pringle?

General Pringle: Thank you, Chairman. There are three things that I would like to add here. First is that we are looking to adopt commercial advances and validate the processes that they are using in the microelectronics chips area, because we need to ensure that what we are getting is adhering to the secure processes that we need. We are also looking to give them, researchers, tools, and we are working

on a prototype for lithography that will meet our very unique military needs and addresses a low-volume production capability, and we are hoping to see that come to fruition this year.

And thirdly, and not least importantly, is developing a skilled workforce, and all of us are working together on developing the capabilities in our teams so that we can be good consumers of the microelectronics and knowing what we are getting. Thank you.

Senator Kelly: Dr. Highnam?

Mr. Highnam: So back in 2017, DARPA announced the Electronics Resurgence Initiative, which is $1.5 billion over 5 years. In that work which is within DARPA is a portfolio of research programs, intel cooperation, and video. All the major U.S. players and some non-U.S. players are participants, both the boundary aspect to the [inaudible].

One thing that is certain is that these days half of the periodic table is involved in these devices. There is nothing simple about them. They have evolved massively over the 40 years ago, since they were introduced. And the [inaudible] DARPA way back, actually, [inaudible] were available to DARPA funding back before the dawn of man, it feels like, but back in the '80s, to make the chip possible [inaudible]. So today, as we look at the evolving worldwide

picture, as you know, the bulk of the semiconductors are made overseas. So we are working to bring it back onshore.

Then, behind that is the packaging. There is the new types of design. There is working with existing designs to make them secure, and we saw [inaudible] over the last couple of years in existing hardware. We announced a [inaudible] with Intel about a month ago to do exactly that, to working with security at two sites.

So for us it [inaudible] systems, from the initial [inaudible] all the way through. We have to address that for our nation's security.

Senator Kelly: Thank you, Doctor. I now recognize Ranking Member Ernst.

Senator Ernst: Thank you, Mr. Chair, and again, to the witnesses, thank you very, very much for being here and testifying. And, Dr. Highnam, I appreciate our conversation a few days ago, and really appreciated the insights that you were able provide.

The Department of Defense has developed a top ten list of modernization priorities that represent technology focus areas from the National Defense Strategy. And they include artificial intelligence, biotechnology, autonomy, cyber, directed energy, fully networked command, control, and communications, microelectronics, quantum science, hypersonics, space, and, lastly, 5G.

How do you assess, Dr. Highnam, the United States standing amongst our global competition to develop, adopt, and deploy these technologies for national security, especially in light of significant commercial sector investments and progress in development of emerging technologies.

Mr. Highnam: Great. One of the most important questions. Over the last two decades we have seen the democratization in technology and science worldwide. So everything we have access to, they have access to, all that. They can be more focused than we are, in some ways. Certain countries, there is an alignment of both civilian and military structures in ways that we are not.

I have viewed this for a decade now, myself, as a [inaudible]. We have to work really hard to stay in the lead, and we are, and I see no reason that that will not be the case across the board.

Senator Ernst: And what specific recommendations then do you have for actions in policy programs or organizational reform that this committee or the DoD should pursue to improve the Department's ability to develop, adopt, and employ these types of technologies for national security?

Mr. Highnam: I think the presumption of the question is that it is your [inaudible] solved. I think it is for us to solve, and we work well together. We work well in the

Department. There is a lot more we can do. I am sure there will be specific pain points and such. But certainly at DARPA, everything we do, we work with the external ecosystem to build results. We are bringing people from there and we send them back to there. And the only reason they come to DARPA is to make a difference, and ambition.

So I think it is our problem to solve -- thank you for the offer -- but hold us to account.

Senator Ernst: Thank you, and thank you for working so well and collaborating together. That is very important as well.

Major General George, there is a former Chinese Chairman that remarked that China would implement the medium and long-term program for science and technology development to make China an innovative country and enhance national strength. And China does aim to be the world's science and technology leader by the year 2050.

What do you see as the biggest challenges related to ensuring a sufficient and competitive supply of S&T talent in the United States?

General George: Senator, I would start by saying I think you are spot on that our people are the foundation and the rock of our future success. And for us it is creating a flow of STEM, the sustainable STEM personnel, from K through 12 right now, that is sustainable through the future.

So it is a whole-of-government, a whole-of-nation issue that we have to wrestle with to put the right policies and for us to have the right authorities to work with our universities to pull in expertise. But it is that flow of STEM that I think is the largest single factor for our future success, to have the talent in the right place and in the right competencies.

Senator Ernst: And are there discussions then, openly, with universities or colleges or other areas of academic where you are letting them know maybe what we need as a military so that you can work on program development, whether it is in K-12 or at our universities?

General George: Absolutely. As a matter of fact, we have got a program with a couple of universities in North Carolina as well as Tennessee that will work directly with our soldiers to help establish what are the problems, and then as a result of that, we are informing our universities on the problem sets if we actually have a soldier in formation level.

Senator Ernst: Okay. Fantastic. Thank you, Mr. Chair.

Senator Kelly: I now recognize Senator Kaine for 5 minutes.

Senator Kaine: Thank you, Chair Kelly and Ranking Member Ernst, and thanks to our witness.

General George, last year the DoD launched something called Project Pele, and that was to design, build, and demonstrate a prototype mobile nuclear reactor that is intended to be safe, avoid concerns associated with existing nuclear actors, and revolutionize how the Military Services deploy and operate, possibly eliminating the need to take energy by fuel trucks back and forth to forward deployed bases.

Could you give us some information about the status of Project Pele, and at what point in the sort of planning and development of this might the Army contemplate incorporating a microreactor into its operations?

General George: Senator, I know from a conceptual perspective how we operate [inaudible] gathering and looking at how we fight differently. But if I could take that question for the record, I will get you an update.

Senator Kaine: Excellent. I would be happy for that. Thank you, General.

General Pringle, I chair the Readiness Subcommittee, which is sort of acquisitions and installations and then readiness metrics. One of the areas that I oversee through that subcommittee is the military construction budget. My observation has been that every military base has a really strong advocacy for its build time projects, not only through chain of command but usually there is a surrounding

community that advocates strongly. And I have wondered sometimes whether there is sufficient advocacy power behind not our bases but public shipyards, armories, DoD research labs.

What is your assessment of the facilities that you oversee in your current position, and are they appropriate for the types of technologies that you are working on, and do we need to pay more attention to them as we work on a MILCON budget?

General Pringle: Senator, this is a great opportunity for me to highlight the authorities that this subcommittee has authorized, and FLEX-4 is one that I would like to thank you for this authority. This has enabled us to make improvements in a variety of lab facilities, and particularly what we have been able to do through FLEX-4 is dedicate, we dedicate, at the Air Force Research Lab -- all of us dedicate a certain percentage -- we dedicate 4 percent of our total obligation authority toward infrastructure improvements. The way that we employ this is through minor MILCON. It seems to be more conducive to the S&T projects that we are working on and the needs that our bench has. That is a $6 million limit right now for UMMC, and if that were potentially a higher value that would also be beneficial. But we have been able to leverage it quite a bit for those purposes, and we are very grateful. Thank

you.

Senator Kaine: Great. Thank you for that. And this is a question really for anyone. We do things in the committee, and I sometimes wonder, or worry, that we do not go back a couple of years later and ask ourselves, "Well, did it work out the way we hoped? You know, too hot, too cold, just right. Here's one."

In 2016, the committee made a number of changes to the Department of Defense to improve acquisition outcomes. One of the changes we made was to split the Office of Assistant Secretary of Defense for Acquisition, Technology, and Logistics into two under secretariats, the Under Secretary of Defense for Research and Engineering and the Under Secretary for Acquisition and Sustainment.

Five years into this, what is your sense of whether that split has had any major impact on how we operate? You know, did we get it right? Should we contemplate adjusting it? Have we created consequences we did not foresee at the time? And obviously your candor is appreciated on this.

General George: Senator, I do not have a way of judging how it was before. The relationship that we have with R&E is working well. We have some of our science experts that coordinate and collaborate routinely with their communities of interest. And so I, unfortunately, do not have a comparison to use in this case, but it seems to me to

be working well as it is currently structured.

Senator Kaine: Your frame of reference is the current framework.

General George: Exactly.

Senator Kaine: Any others worked under the past frame of reference to have a point of comparison?

[No response.]

Senator Kaine: Okay. All right. Thank you for your answers, and I will submit that first question, just a QFR, just to be very precise about it, and I would love your answer to that, General George.

Thank you, Mr. Chair.

Senator Kelly: Thank you. Senator Cramer is recognized for 5 minutes.

Senator Cramer: Thank you, Chairman Kelly and Senator Ernst. Thanks to all of you for being here, for your service.

Now I know something, General Pringle. Whenever I go to Grand Forks and Colonel Pringle brags about his smarter, older sister, I just thought he was guilty of false humility. Now I know he is telling the truth. It is great to meet you. But I am sure hopefully he has shared with you some of his experience in Grand Forks and let you know that we have a great relationship.

Admiral, when you were talking about STEM and

specifically targeting, for example, the HBCUs, a great example of a potential workforce that might have been neglected before but presents tremendous opportunities, both for them and for you. I would say, likewise, in the middle of the country there are a lot of smart people, K-12 as well as in our universities.

I think North Dakota is a good example of that. We have great relationships between our bases and our universities. We have great relationships between our industry partners, the tech parks, and our bases. And, frankly, Grand Forks is a good example where the radar at Grand Forks is being used to allow industry to fly UASs without chase ships. That could not be possible without that relationship, in the middle of the country.

So we also have a very good state government that is cooperative and collaborative and really eager, and they have done amazing work in making North Dakota the number one-rated UAS-ready state.

So we have this middle America that needs to understand that their investments into future technology and that understanding does not materialize when all the tech efforts take place on the coasts. So what is the best way to get the military to utilize the great tech environment that we have built up in the middle of the country, and specifically in North Dakota? And I would let any of you answer that

question, if you have it. But I know that General Pringle has an insight.

Admiral Selby: I will start if that is okay. So I would say that, you know, we have found that in this COVID environment, Zoom, Teams, we can now reach so many more people, and we can use that forum to actually reach into communities we have not traditionally reached into. Now, hopefully we are going to be able to travel again more, which will be actually nice as well, but I think even when we can travel we should do hybrid events to try to bring in as many people as we can. Small Business Innovative Research, SBIR program. That is a tremendously valuable program. It is very powerful. It allows us to reach into small businesses in places like North Dakota, Iowa, you know, wherever, that we just have not done before. A lot of times we get kind of locally centric around our bases. We need to expand that. We need all hands on deck across this country to help us with this problem. It is a team of teams, and wherever they are, we need to go after them.

Senator Cramer: Excellent. Doctor?

Mr. Highnam: We recognize the opportunities there as well. We have been cognizant -- DARPA has been doing outreach events. We were doing them in person, so Nebraska was the first place. We went to Lincoln, with the help of the local Chamber and the university, a great couple of

days.

Sitting at DARPA we think everybody knows how to work with DARPA, which is the other side of this. So we begin with working with DARPA is a contact sport and we are here to help. We explain what we are doing. We explain the different mechanisms we have available, some of which really are tailored for fast response to small businesses, universities, and so on, who have not worked with us before, and we are there to help mentor.

Most recently, North Carolina, working, again, as the Admiral said, working a statewide body to help do that, and I think we have one coming up with Arizona, because we were spoken to by Business Arizona as well. So the same type of thinking.

There is a ton of talent. We have to introduce us to them as much get them to introduce themselves to us.

Senator Cramer: Sure. General?

General Pringle: If I may add, thank you, Senator. Aside from having a brother in one of these great states and leveraging the connections there, there are authorities that, again, this subcommittee has provided, and it is through Section 244 that enables us to build consortia and to open the doors with universities and industry.

So we have modeled some new regional hubs, based on what the Army has done with their regions, and we are

establishing them in areas where we have not traditionally been focused. The Midwest is one of them, as well as the Northeast.

So I think that will increase attention to those areas where establishing, for example, a Space University Research Initiative and providing money to universities that want to partner with us, this is a $6 million endeavor over 3 years, which really attracts a wide variety of universities and talent.

And, finally, we have a number of manufacturing institutes across the nation that help us partner with industry. And it is focused on a particular area, that is manufacturing, but as you mentioned, Senator, a lot of talent out there that we can leverage for our S&T purposes. Thank you.

Senator Cramer: Well, I would love to invite you to Grand Forks and to the University of North Dakota, and perhaps for Colonel Pringle's change of command later this year.

Thank you, Mr. Chairman. I yield.

Senator Kelly: Senator Warren is going to join us via Webex, and is recognized for 5 minutes.

Senator Warren: Thank you, Mr. Chairman.

So one of the things I have talked about a lot as a member of this committee is the importance of basic and

applied research funding. Early-stage research is critically important as the foundation for our nation's ability to develop new technology, and it pays off, many times down the road.

But too often early-stage research can get overlooked. For example, while the total RTD&E budget grew by 51 percent from fiscal years 2015 through 2020, basic and applied research funding was essentially flat, and the Department's FY 2021 request for S&T funding was actually one-half of 1 percent less than it was in the year prior.

So my question is to our military officers, and I am just going to start with a simple yes/no here. Do you all agree that basic and applied research is critically important to our technological advantage? And let me just start with you, General George.

General George: Senator, Yes.

Senator Warren: Good. Admiral Selby?

Admiral Selby: Yes. Yes, ma'am.

Senator Warren: Good. Thank you, Admiral Selby. And General Pringle?

General Pringle: Senator, yes, emphatically so.

Senator Warren: Emphatically so. I like that even better. Thank you.

You know, university-affiliated research centers, or UARCs, play a pivotal role in basic and applied research.

Now I cannot ask the Air Force my next question because the Air Force does not have UARCs. So, General George and Admiral Selby, do you agree that UARCs provide the Army and the Navy with a good return on investment and are critically important to your Service's R&D goals?

General George: Senator, yes, and can I just, if I can, elaborate. MIT Institute for Soldier Nanotechnologies is a great ecosystem for us that combines soldiers and our academic institution and has promising outcomes.

Senator Warren: Good. I am glad to hear that.

Admiral Selby: And, ma'am, from the Navy, as I am sure you are well aware, we have 5 UARCs. They all have some very unique capabilities. They support us in everything from R&D through in-service support of our sailors and Marines across the fleet. So they are critically important to our success as a force.

Senator Warren: Good. Well, I appreciate that. I hope our Air Force witness heard that.

You know, in addition to helping accelerate our research and development goals, UARCs also play an essential role in the broader economy and in the defense industrial base. Since 2002 -- you raised the research at MIT -- the Institute for Soldier Nanotechnologies, or ISN, has led to the creation of 28 successful small businesses. That is 28 new businesses that are hiring workers right here in

America.

Unfortunately, the ISN has seen its funding decrease from $9.5 million in 2014 to $4.4 million in 2021, and will potentially drop further to $3.9 million in 2022.

So, General George, briefly, can you tell me why the Army has been steadily cutting funding to the ISN?

General George: Senator, the Army has been equally funding at this point across the four UARCs that we have, and so it is a leveling of the resources that go to each of the UARCs. You know, we have one in California and one in Georgia, Georgia Institute of Technology, as well. And so it is a part of the balance as we look for all innovative approaches in the ecosystem that we have with our universities.

Senator Warren: Well, I understand you are balancing, but my understanding is you are cutting ISN funding overall. Look, I get it. You need to make difficult choices in your budgets. But I have two concerns, one, that the Army is neglecting an important research area in nanotechnology while it is chasing other priorities. But as you know, research at the ISN has directly contributed to each of the Army's six modernization priorities.

And then, second, basic and applied research, more broadly, is the seed corn of our technological advantage. If the Department fails to properly tend to this field, we

will find ourselves with nothing to harvest, far behind our competitors on the technologies of the future, technologies that we do not even know about today.

So I am going to continue to push for DoD to fund more on this, because I think it is important.

So thank you all for being here, and thank you, Mr. Chairman.

Senator Kelly: Thank you, Senator Warren. And Senator Blackburn, via Webex, is recognized for 5 minutes.

Senator Blackburn: Thank you, Mr. Chairman, and thank you all for being with us today.

General George, I want to come to you. I know that you are aware that University of Tennessee and Vanderbilt are the first Pathfinder partnership for the Army Futures Command. And we fully appreciate. We know what that means to our state, and we appreciate that these academic researchers get to interact with the fabulous troops at the 101st Airborne and also the 160th Special Operations Aviation Regiment there at Fort Campbell. And they are working on next-generation technologies and end-user insight. This is a solid partnership.

So what I would like to ask you, for the record, is what are the Army's biggest lessons learned from implementing this program? How could these lessons be used to inform future partnerships for emerging technologies?

And then how could you take this Pathfinder model and have it inform the efforts of the Services and DoD, more generally?

General George: Senator, thank you for that. So the Catalyst Pathfinder Program, as you well know, is really in its infancy. We have got a great start, especially with Vanderbilt and, as you mentioned, the 101st Airborne. And so I think what we have got to do is watch to see how the interaction between our soldiers and the academic institution, the scientists there, plays out. And one of the things we are doing is ensuring that one of our research leaders from the Army Research Lab is partnered there as well. And so as you just described, we have got to learn how this works and what the outcomes are.

So we are going to be looking for the outcomes to see if there are valued solutions that are proposed that could feed into Army priorities, and certainly then look to see if this is some program that we would like to expand.

Senator Blackburn: Okay. Do you feel like you are fully maximizing the partnerships that you have in play now?

General George: With the Catalyst Pathfinder partnerships, like I said, I think we have got to do some learning still. We are further along with the partnerships in Tennessee, and we are --

Senator Blackburn: So you have room to grow with

those.

General George: Yes, I do believe we do.

Senator Blackburn: Okay. All right. Let me talk to you a little bit about workforce and workforce development, because we are always focused on great power competition, China and Russia, and we know that workforce is really crucial to develop and implement some of these emerging technologies. An important part of this effort for DoD and commercial industry is to create robust and competitive hiring pipelines for STEM professionals.

And what I would like for you to touch on is what would be the threat to our warfighters if we were to lose the advantage we have now in AI? I included a provision in last year's NDAA authorizing the direct hiring of AI professionals. So I would like for you to touch on how that direct hiring affects or supports the work that you are doing.

General George: Senator, for the Army, we are liberally using the direct hiring authority, and it has been a very powerful tool for us to bring in talent at the speed that we need it.

Senator Blackburn: Thank you. I appreciate that. I think that as we look at these emerging technologies, this is going to be so important for us.

One other question I would love to ask you, as we talk

about AI talent and the Federal workforce and the military, what role do you see for the National Guard and our reserve components playing in this endeavor to increase this talent pool?

General George: Senator, we are partnered with the 75th Innovation Command, which is a reserve command with Army Futures Command, and they have been very helpful bringing expertise into every conversation we have. And, in particular, since we have them and our AI Integration Center in the same command, under Futures Command, it has just increased the collaboration that we have.

Senator Blackburn: Excellent. Thank you. Thank you, Mr. Chairman.

Senator Kelly: Thank you, Senator. I am going to go to the next round of questions. There has been a lot of discussion here in D.C. lately about infrastructure spending. How do all of you -- well, I guess with this question it is probably not suited for DARPA, because it is about testing infrastructure. So for the admiral and the two generals, how do you work to maintain world-class research and testing infrastructure? For example, you know, places like the Yuma Proving Ground in Arizona, or Fort Huachuca's Electronic Proving Ground, or Pax River, where I used to fly in the test range, White Sands Missile Range, Nevada Test Range. I mean, how do you work to maintain that

infrastructure in those places, and places like them?

Admiral Selby: I will start. So, you know, as you are aware, sir, we have many warfare centers across the Navy -- Carderock, Dahlgren -- all those are different warfare centers. We do a phenomenal amount of testing at all of those centers across the country.

You are right. The budgets are pressurized right now, but General Pringle mentioned some of the special authorities here, so we are able to use some of our S&T money to do some of the MINCON, so minor MILCON. That gets after some of it.

When we do have bigger projects that do come along, and they do not come along all the time, but when they do we have to really work hard to get them prioritized on the list. That is a challenge, because obviously the Navy and Marine Corps have got big bills. But, you know, when you can show the actual benefit of what we are doing for the warfighter that is relevant, because if you do not do this testing or this S&T work in a laboratory, we will not have the capability. That sells, and we are able to get these things approved. Again, it is not every year. Sometimes we have to wait a few years. But those laboratories are just absolutely critical to our ability to maintain our warfighters to be ready to deter, and, if required, to flight.

General George: Senator, for Yuma, you mentioned specifically, we have had great success, even during COVID. We had testers at Yuma that were able to conduct our experiments and videotape to our engineers who were sitting Picatinny, New Jersey, so that we could keep our projects on track during COVID.

So the more we use our test centers, the better off they are going to be, because that is how they receive their resources, and then we are able to resource, through our projects, increases in modernizing their capabilities as well.

General Pringle: Chairman, the two examples I would like to provide from a departmental standpoint, Department of the Air Force, is we have a different setup where the Air Force Test Center oversees our test infrastructure. However, from an S&T standpoint, we partner with them and, frankly, we embed some of our scientists and engineers at those locations to really get the benefit of cutting-edge science to ensure that it is going to the right test. So whether it is Edwards, or just on Monday I was at Arnold Air Force Base and looking at the test infrastructure there, we get a synergy between looking at how we can improve our S&T infrastructure to support that mutually beneficial goal.

Senator Kelly: General Pringle, is there anything that this committee could do to help build the research and

testing infrastructure beyond what you currently have, build it out to -- and this question is really for all of you -- I mean, anything else that you need, what could our subcommittee do to provide that?

General Pringle: Mr. Chairman, I would say that the authorities that we have are really great, and we have used them to the greatest extent possible. The FLEX-4 we really appreciate. If you were thinking about potentially an increase to the ceiling on minor MILCON that might be helpful. It is set at $6 million right now. But other than that I very much appreciate the authorities we have been given.

Admiral Selby: I would say, sir, just continued support for S&T across the board is what we need to continue to do the great work we are all doing at these laboratories.

General George: For the Army, the test community is responsive to the Army Futures Command for prioritization, but they are not actually resourced through the same mechanisms that we resource our research and development community. So again, we have a great partnership. The more that we work with them, I think the better off they will be, as well.

Senator Kelly: Thank you. Senator Shaheen is recognized for 5 minutes.

Senator Shaheen: Thank you, Mr. Chairman, and I

apologize for missing the testimony. I was up in the Small Business hearing where one of the topics that came up was the SBIR program. And knowing that you were talking about innovation and technology, I thought it would be important to raise the issue here, in this hearing, to hear what you all think about the importance of the SBIR program, what you have seen, whether it should continue and be reauthorized. So I do not know who would like to start with answer that.

General Pringle: Senator, I would like to take that. Heather Pringle from Air Force Research Lab. We see the value of Small Business Innovative Research and we have fully embraced its use, especially in the last year, and we have done some really unique things with our program. First of all, we had it join our AFWERX team, and so we have one-stop shopping for innovation. And what they are doing is blowing the doors off of partnering with small businesses, and trying to make it more accessible and lower the barriers to entry to the Department of Defense.

So if you hear the word "AFWERX," then that makes it easier. And, in fact, if you look at our numbers from the last year, we awarded over 2,000 contracts to small businesses, and 75 percent of those contracts were to new recipients, or new partners with the Department of the Air Force. And what that does is it provides us with a new source of innovation, and only benefits our ability to

provide better S&T.

Senator Shaheen: Thank you.

Admiral Selby: Yeah. I will just add, we have done something similar, and we have also kind of broadened our solicitations so they were not too specific. We made them less specific. We found we got many, many new applicants we have not seen before, and we have also used virtual to actually expand our reach. So we have been having virtual meetings and bringing in hundreds, where before you might get dozens. So we have gotten many, many more solicitations. We have shortened the required inputs, sped up the contracting cycle to get the money out the door faster, to keep these companies energized. They are critical to our success as a nation, no question about it.

Senator Shaheen: Thank you.

General George: Senator, I would just echo what my partners here said. In the Army, at the Army Futures Command, they have also taken an innovative look through the Army Applications Lab, very much like AFWERX, to reach some small businesses that previously we have not been able to get to.

Senator Shaheen: That is great. Anything else, Dr. Highnam?

Mr. Highnam: Thank for the question. We make extensive use of the SBIR/STTR authorities. We also are

looking at our numbers. Spend about 18 percent of our annual budget with small businesses overall. And so that is coming in competitively through the SBIR/STTR programs while coming in as competitors on the regular programs.

If I may, there is one extension that we have taken, looking at how to protect some of these small businesses as they seek to grow, in terms of the sources of capital that they pull on. And we have launched something called the Embedded Entrepreneur Initiative, initially a pilot of 30 companies in microelectronics and biotechnology, over 2 years. The objectives was to have them take U.S. venture funds, and now we are scaling that up to 150.

Senator Shaheen: Great. That is great. Thank you all very much.

Mr. Chairman, we reauthorized the SBIR program through the NDAA Act in 2017 for 5 years. It is set to expire again in 2022, so I would argue that this is something that we should get refocused on and think about how we get it reauthorized. Thank you all very much.

Senator Kelly: Thank you, Senator, and I recognize Senator Ernst for 5 minutes.

Senator Ernst: Yes, thank you, and I would agree with Senator Shaheen. I think it is really important that we work in that area together, and, General Pringle, those small businesses are critical to our defense industry and

they are disadvantaged. And so just as Senator Shaheen was pointing out, we really do need support for those businesses to make sure that they are able to tap into that network and, of course, be able to share their developments with our defense industry. So they can be very, very helpful in our modernization efforts.

Again, if you would outline some of those major barriers, and are there, for the small businesses tapping into DoD and acquisitions, and as well, what can we do differently? On top of programs that are already being offered, are there other ways that we can leverage these small businesses?

General Pringle: Thank you for the question. As you mentioned, the small businesses are really vital to increasing our sources of innovation, and in addition to making it more accessible for them to partner with the government and with DoD, we have set up a series of phases where they can graduate from Phase 1 to Phase 2, and we have been trying to partner them with warfighter so that they look at the application of what they are doing sooner than what they might have. And we are also looking at opportunities for them to get some venture capital and to see if maybe they can raise some funds on their side. And through some of those efforts, these businesses and venture capital have been able to extend the DoD's investment in

these small businesses, and we have been seeing an increase in the return on investment.

So not only by the DoD investing in them but them getting a partnership funding that they are able to grow and expand.

Senator Ernst: Thank you. Yes, Admiral, please.

Admiral Selby: If I could just add, what we have done is we have NavalX, much like AFWERX. We use that in addition to these Tech Bridges we set up around the country to actually conduct training. So we actually do training to teach companies how to actually work with the government, because a lot of them have no idea. So we are reaching out to kind of non-traditional businesses, and then we are providing training so they understand. It is available to anybody so it is a level playing ground, but we let them know how you do business, here is how you fill out the forms, here is what you have to do, here is who you have to talk to. So we train them.

Senator Ernst: That is exceptional, and you do receive a large turnout in participation?

Admiral Selby: Yes, ma'am, and when we do it virtually, even more. That is what has really opened the doors here, because the virtual presence actually allows us to expand this far beyond what we would do if it was just in person.

Senator Ernst: That is fantastic. I appreciate that. And while we are with you, Admiral Selby, when we spoke yesterday you listed AI as a technology high priority area, and you also mentioned autonomous and unmanned, quantum, hypersonic, 5G, and biotech as areas for study and application, all very important. All of these areas are showing some tremendous promise for application and advantages in our warfighting. Can you go ahead and describe for us the critical factors needed from Congress to ensure that these technologies are brought to fruition?

Admiral Selby: I think it is pretty clear that this century is going to be basically ruled by whoever can make the decisions faster and more accurately than the adversary. It does not have to be right all the time but it has to be right more often than they are. And AI, machine learning, is going to be what will enable that for us.

So we have got to continue to conduct the research in those areas. We have to continue to do experimentation in those areas. We have to get the warfighters engaged to actually provide their input early. That is what we are doing right now in San Diego with this Integrated Battle Problem. We have got systems off the coast right now, unmanned systems, that are involved in a realistic battle scenario, and we are collecting that information, and that will go back into the laboratory to do additional research.

So the funding that you provide, the S&T funding, is going to enable that.

Senator Ernst: Fantastic. And I yield back. Thank you.

Senator Kelly: Thank you, Senator. Senator Peters is recognized for 5 minutes.

Senator Peters: Thank you, Mr. Chairman, and thank you to each of you for your testimony here today and for the work that you do every day for us. Incredibly exciting area that you are in, and one that changes, what, on an hourly basis? It is really highly dynamic so thank you for keeping up on all of that.

Actually, I want to pick up on the questions from Senator Ernst related to AI, and thinking about AI but also in relation to cybersecurity. Dr. Highnam, you mentioned in your written testimony, your work identifying cyber vulnerabilities and attributing malicious actors to specific individuals. And as I am the chairman of the Senate Homeland Security Committee -- in fact, we just had a detailed briefing on the SolarWinds today, and we have had a hearing on that and dealing with cyber threats broadly across the board -- and Admiral Selby just talking about the innovation with AI and it is the next big thing that will transform warfare and transform our societies, I want to talk about how you put the two together, the fact of

vulnerabilities of AI through cyber vulnerabilities.

My question is, how concerned are you about the possibility of malicious actors co-opting some of our AI infrastructure to actually manipulate the algorithms that are the heart of all of that, to produce inaccurate feedback? And if you have inaccurate feedback you have really bad decisions. So talk to me a little bit about what you see and what keeps you up at night in that area.

Mr. Highnam: AI is a technology. It runs on computer. So, as you say, computers help us make bad decisions faster.

Senator Peters: Yeah.

Mr. Highnam: I think that was the line. So when we talk about AI technologies, we are building on decades of work in signal processing and decision-making by machine. And what these AI technologies are doing, as we see them, is adding speed and flexibility where we did not actually know a physics solution, a closed solution, that we could code in absolutely, or rules to be learned. So many opportunities then for malicious actors to be involved.

One of the undergraduate student party tricks is to take a trained computer vision system, put a sticker on it, and this is changing a stop sign into a recorded -- turn a stop sign on a road into a 40-mile-per-hour sign.

Senator Peters: I have seen that, yeah.

Mr. Highnam: So these are party tricks. To the point

about the attack surface, which you are talking to, we have expanded it by adding these additional capabilities.

So DARPA has a lot of work going on in that space, looking at the challenges of poisoned data set for training, the challenges when someone has access to a model or knows the model that you are using, or has conventional access, conventional cyber-attack access to the computer again, which it is running on, or computers, or the sensors that it is running on, to cause a thing to happen that you do not want.

A lot of work underway, defense work, at DARPA, against this. And then if you step it up a little bit you get into information operations and media forensics and deep fakes, in another sense. For us this is a continuous spectrum, and we are involved in many programs, research programs, across that space.

Senator Peters: Yeah, critical. Good. I would love to talk to you more about that at some point.

Mr. Highnam: Love to.

Senator Peters: General George, welcome. I deal with one of your subordinate commands on a regular basis, GBSD just outside of Detroit, that does amazing R&D work for the Department of the Army. I know you already know that but I will give you another plug for them. The men and women there are truly exceptional, and we are looking for them to

design the next-generation combat vehicle, which is some pretty exciting stuff.

My question for you is, I just recently got back from a visit to Yuma Proving Grounds in Arizona, to see first-hand some of the work that you are doing with the drones and counter-drones, a threat on the battle space but a threat to the homeland security as well, where you have got these very small drones in swarms, potential swarms of those. Very difficult to defend against, and as active in the battlefield, we see what Azerbaijan has done with these types of weapons as well, that is really starting to change our thinking about how we deal with them.

So if you could talk to me a little bit about that work that you are doing, what is happening at the Yuma Proving Group, but where do you foresee that going. What are the major challenges that you face? How can we help here in Congress to further support your efforts to make sure we can develop the kinds of countermeasures necessary to keep our warfighter safe but also our civilians here in the homeland?

General George: Sure. The work that is going on, Senator, at Yuma, is actually under the Joint Counter UAS Office, that is led by the Army, in this case. So they are looking at a lot of commercially available things ready today, and we have got to learn how to use them in the hands of our soldiers and formations. So it is a combination of

the technology and the formations and the concept and the doctrine on how they are used.

Inside of our labs, we are providing a great deal of technology that feeds into those system, that will help either with an RF track, sensing, and then detecting, and AI actually helps to engage nearly automatically.

So a lot of great work, and as you said, the Ground Vehicle Systems Center in Detroit is leading for the protection of our platforms and certainly is following along with the Joint Counter UAS Office.

Senator Peters: Yeah, good. Thank you. Thanks for the work you are doing. I appreciate it.

Senator Kelly: Thank you. And thank you, everybody, for coming today. I just want to ask one more question to all of you, if there is anything you felt we should have asked, anything you need to make sure that our soldiers, sailors, Marines, airmen, guardians have the best technology in the world? I mean, what do you need from the United States Congress so you can do the best job you possibly can?

General George: I will start with just three quick things, Mr. Chairman. One is, of course, continued resourcing, predictable resources. The second is the authorities that you have given us, keep them coming, because we use them, they help us, they help us in our laboratories with our people and our infrastructure. And

the third, frankly, is patience, to allow us to develop and look into the future, at the technologies that just are not incremental improvements but are transformation. And so the resources that we want to use are to get the transformational capabilities out beyond the next 10 to 15 years.

Senator Kelly: Admiral?

Admiral Selby: I would say that continued support in the S&T realm is really important. Senator Warren said it, but, you know, sometimes it is hard to kind of explain what you do in the 6.1 and 6.2 world. But what we are trying to do is develop knowledge, technology, and people, people that have the insight, and that is critical to furthering our capabilities in the science and technology world that will one day become capability. So continue to support that, and I would say, in addition to the existing authorities that we already have, the Small Business Innovative Research is critical to having that continue for our success.

Senator Kelly: Dr. Highnam?

Mr. Highnam: First, again, echoing support. Direct hiring authority is very important for DARPA, among other support that you provide. We move quickly, and that is key to doing that.

Second, as seen with the partners here, it did not come up in detail but we make extensive use, and work with them.

They say "exchange prisoners." Their people come work at DARPA for tours. Our people go there. We use the testing infrastructure. We use the subject matter expertise. It is deep in these places that we do not have, because, by design, DARPA people, myself included, are ephemeral. We do a tour; we leave. These folks have hypersonics expertise in Eglin that has been developing in one place for decades. It is enormously important. So we need those strong partners.

And third, a newer one, perhaps. There is an increasing emphasis on supply chains. We talked briefly about microelectronics, when we spoke sometime in the last week. We talked a little bit about medications and what that has meant through COVID, and the work that we have been doing to battlefield medicine, for example, medicines in austere conditions, now bringing it back to the U.S. And this is, for example, there are several small companies that we have helped to foster and creating working in that area. But then beyond that, chemicals. We talked about microelectronics and sand to systems. At the beginning of that whole process there are basic chemicals. When we talk about visors or protective gear for biosuits, where do these specialized chemicals come from? Too often, not here.

So we are very interested in this as a manufacturing, almost as a problem, but supply chain in general. And the fact that DARPA is spending much of its time thinking about

how to secure supply chain issues is time we are not spending on other things. So we have to do it, and your support and recognition of that would be much valued.

Senator Kelly: Thank you, Doctor. And General Pringle, final word.

General Pringle: Thanks, Mr. Chairman. I echo and support everything that my colleagues here today have mentioned, and just would add a couple of things. First, as we build the A-team to meet the challenges of the future, we do not know what the threat will be, and so extending our partnerships wide is really important. So continue the authorities that help us build strong consortia.

We have to balance the ability to partner with the ability to protect, and to build a critical U.S.-skilled tech workforce. And so that is another balance that we will need to make going forward.

In addition, the authorities that you provide to give us greater access to tools and infrastructure I think are very, very helpful, and particularly in the digital realm. So the one thing that is going to help us go faster in the future is that digital connectivity and digital infrastructure that underpins it all.

So I really thank the committee for all their support, S&T and the authorities that you have provided.

Senator Kelly: Well, thank you. Thanks to all our

witnesses for participating. This was very valuable and an important hearing, and we look forward to working with everybody in the future. And this hearing is adjourned.

[Whereupon, at 4:04 p.m., the subcommittee was adjourned.]