

THE DEPARTMENT OF DEFENSE'S POSTURE FOR  
SUPPORT AND FOSTERING INNOVATION

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HEARING

BEFORE THE

SUBCOMMITTEE ON  
EMERGING THREATS AND CAPABILITIES

OF THE

COMMITTEE ON ARMED SERVICES  
UNITED STATES SENATE

ONE HUNDRED SEVENTEENTH CONGRESS

SECOND SESSION

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# **THE DEPARTMENT OF DEFENSE'S POSTURE FOR SUPPORT AND FOSTERING INNOVATION**

**WEDNESDAY, APRIL 6, 2022**

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

The Committee met, pursuant to notice, at 2:30 p.m. in room SR-222, Russell Senate Office Building, Senator Mark Kelly (Chairman of the Subcommittee) presiding.

Committee Members present: Kelly, Kaine, Peters, Ernst, Fischer, Scott, and Tuberville.

## **OPENING STATEMENT OF SENATOR MARK KELLY**

Senator KELLY. Good afternoon, everyone. The Emerging Threats Subcommittee meets this afternoon to receive testimony today, and I would like to welcome our witnesses, Mr. Michael Brown, Director of the Defense Innovation Unit (DIU); Dr. Stefanie Tompkins, Director of DARPA, the Defense Advanced Research Projects Agency; and Ms. Heidi Shyu, the Under Secretary of Defense for Research and Engineering. Thank you all for being here today. I really appreciate you taking the time to do this.

We are going to hear today from leaders who are working to support defense and national security innovation, to ensure that the United States retains its technological superiority and maintains its competitive edge over potential adversaries like China in the technological market space.

This is also a good opportunity for our witnesses to discuss how the recently released fiscal year 2023 defense budget request supports investments that advance the innovations needed to make the U.S. military more effective, more lethal, and more capable than those of our potential adversaries.

I would like to welcome again our witnesses who will help shed light on these topics today, and I want to take this opportunity to again thank you, not only for being here but for your service to our nation. I know all of you share my goal of leveraging innovation to put the most advanced and effective technologies in the hands of our servicemembers and creating a vibrant innovation ecosystem that allows our military to stay more adaptive and more effective than our adversaries.

It is no secret the United States is in a competition with China, who seeks to dominate the national security as well as the commercial technology space. To date, our technological superiority has

been enough to maintain our advantage despite the ambitions and methodical progress of China.

While the United States continues to enjoy an advantage in areas like advanced combat aircraft, missiles, nuclear and space technologies, and land and naval power, it is critical that we continue to show the Chinese Government and all our competitors that starting a conflict or challenging us is simply not in their best interest. Continuing to advance our technological capability is central to that deterrence, as it removes any doubt about our ability to prevail in any head-to-head conflict, if provoked.

It is also important to remember that our national investments in science and technology research ultimately benefit not just the Department of Defense but also the broader American public. Technologies funded by the DOD science and technology program over the past century have helped produce the Internet, the Global Positioning System (GPS), smartphones, advanced materials, and even medical advances that have improved Americans' prosperity, security, and quality of life. Most recently, Department of Defense (DOD) investments in medical research have resulted in the vaccines and therapeutics being used to address the COVID pandemic today.

I also want to emphasize that the innovation ecosystems that the Defense Department supports work best when they leverage state, local, and Federal assets and investments holistically, in addition to the broader academic and commercial entities needed to power effective public-private partnerships. My home state of Arizona is leading on this front. Our universities are driving innovation in critical fields, from advanced semiconductors and hypersonics to quantum computing, and applying advanced data analytics to military challenges like managing complex supply chains and improving operational planning. They are working side-by-side with our military as they do this.

These ties can help us accelerate our defense research programs. We need to foster them, and we need to ensure that we are attracting and retaining the talented personnel and investing in the testing infrastructure, including in Arizona, that makes all this progress possible.

While innovation is something we have historically done better than anyone, we now face an immense threat to our technological superiority. China has been making significant advancements in cutting-edge technologies, like microelectronics and hypersonics, as it seeks to erode our military and economic advantages. They do so through not only dual-use investments but also through corporate coercion, espionage, and their connections between government and industry that would not be conceivable or acceptable in any democratic country.

That is why we must take a strategic approach across all technologies as we are doing now with our plan to boost domestic microchip manufacturing, to bring more of that capability back to America. That will create jobs, it will reduce our reliance on foreign sources, and also mean that we are doing breakthrough research here at home.

So I hope that in this hearing we can examine how DOD, DARPA, and the Defense Innovation Unit (DIU) are using the re-

sources and authorities they have been given to help us win the global technological competition against adversaries like China, by making advancements in key emerging technology areas, including artificial intelligence, autonomy, microelectronics, 5G technologies, and hypersonics. I would also like to ask the witnesses to 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 as they embark on writing our annual defense authorization.

I will now turn to the Ranking Member, Senator Ernst, for any opening comments that she has.

#### **STATEMENT OF SENATOR JONI ERNST**

Senator ERNST. Great. Thank you, Mr. Chair, and good afternoon to everyone. I want to thank all of our witnesses for being here today.

Every one of us in this room agree that increased innovation to deliver lethal capabilities to the warfighter must be a priority of the Department of Defense. It is not up for debate. The questions and policy choices I am interested in deliberating concern the mechanics of identifying, screening, prototyping, and ultimately delivering technology to the warfighter.

The President's Budget promises record levels of investment in research, testing, development, and evaluation. Will the Department translate those dollars into combat capability more quickly, or will projects with bigger price tags continue to die in the valley of death? Barriers like over-classification, continued embrace of exquisite hardware over agile service contracts, and risk aversion to using authorities like the middle tier of acquisition are too high. No budget number can clear them. China is moving quickly and aggressively to adopt emerging technology for their warfighters, and we cannot let the capabilities we provide our soldiers fall behind.

Today I hope you all can help ease my concerns and we can go forward with a commitment to field all necessary systems more quickly and effectively.

Thank you very much to our witnesses. Thank you, Mr. Chair.

Senator KELLY. Thank you, Senator Ernst. Now I welcome any opening remarks from our witnesses, beginning with Secretary Shyu.

#### **STATEMENT OF THE HONORABLE HEIDI SHYU, UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING**

Ms. SHYU. Chairman Kelly, Ranking Member Ernst, and Senators of the subcommittee, thank you for inviting us to represent the Department of Defense at this hearing on accelerating innovation for the warfighter. I am honored and proud to be the Under Secretary of Defense for Research and Engineering and the Department's Chief Technology Officer.

I look forward to this testimony as this is the first time I have been to the Senate since my confirmation, and I thank you for your support during that process. It is an honor to be back working at the Department of Defense.

On behalf of the Secretary, the Under Secretary of Defense Research and Engineering (R&E) sets the technology and innovation

strategy for the Department. The position oversees the Defense Advanced Research Project Agency, DARPA, the Missile Defense Agency, the Space Development Agency, the Test Resource Management Center, and the Defense Innovation Unit, DIU. I am pleased to testify with the directors of DARPA and DIU by my side today.

As the Under Secretary, my responsibility is to ensure an enduring technological advantage for the United States military. We will accomplish this goal by building and implementing the Department's technology strategy. As directed by Congress and in alignment with the National Defense Strategy, the forthcoming National Defense Science and Technology Strategy will provide guidance to the Department on near-term challenges and ensure that our nation remains the global leader in technology far into the future. The challenges are vast, from rising nations to rising sea levels.

In my written testimony I describe the specific critical technology areas and how the Department is working faster and more collaboratively across prototyping and experimentation. Today I want to briefly highlight two areas where the Department must work closely with Congress to ensure an enduring advantage, first, building a strong foundation for science, and secondly, updating how the Department does business to better reflect today's world.

Every strong structure needs to stand on a solid foundation. To ensure this country retains our edge and fuels future technologies as capabilities, we must make a commitment to science and technology, particularly in the basic research. We must attract the best people. We must supply the necessary infrastructure for research and development (R&D). We must rapidly prototype and perform joint experimentation and collaborate across the technology ecosystem.

If we expect the Department to attract the world's best and brightest to produce state-of-the-art technologies, we must modernize our laboratory and test ranges. The future of the Department depends on talented people, and we are committed to developing this talent. The Department has invested in a variety of workforce educational and research programs, ranging from K-12 robotic systems to Science, Technology, Engineering and Mathematics (STEM) scholarship and social science research. As the strategic competition increases so must our attention to Science and Technology (S&T).

I know many of you on this subcommittee feel the same way, and I look forward to working with you to strengthen our S&T, its supporting infrastructure, and the workforce.

In my remaining time I want to discuss how the Department must innovate in pace with the technological change and keeping with the demands of national defense strategy. Historically, the Department has been a leader in R&D. We still are, but the growth of private sector R&D has exploded over the last 50 years.

As seen in Ukraine, novel commercial technologies paired with conventional weapons, can change the nature of conflict. The Department's processes, ranging from programming to experimentation to collaboration should be updated to reflect the dynamic landscape of today and anticipate the needs of tomorrow. Our Nation's private sector is our competitive advantage, and we must



focus on improving how the government and private sector work together.

I am committed to working with you to ensure the Department can move as quickly as possible as it engages with the private sector and the whole innovation ecosystem to rapidly transition technology through fieldable capability.

Thank you for having us here today. We will all look forward to your questions.

[The prepared statement of Ms. Heidi Shyu follows:]

PREPARED STATEMENT BY THE HONORABLE HEIDI SHYU

Chairman Kelly, Ranking Member Ernst, and subcommittee Members thank you for inviting the Department of Defense to provide testimony for the Senate Armed Services Committee hearing on accelerating innovation for the warfighter. I'm honored and proud to be the Department of Defense's Under Secretary of Defense for Research and Engineering (USD(R&E)) and Chief Technology Officer (CTO). I am pleased and appreciate the opportunity to discuss these important topics. I look forward to this testimony as this is the first time I have been back to the Senate since my confirmation. Thank you for confirming me to this role; it is an honor to be back at the Department of Defense.

On behalf of the Secretary of Defense, the USD(R&E) sets the technology and innovation strategy for the Department of Defense, and oversees the Defense Advanced Research Projects Agency (DARPA), the Missile Defense Agency (MDA), Space Development Agency (SDA) and Defense Innovation Unit (DIU). I am pleased to have the Directors of DARPA and DIU by my side today. The Department's goal is to provide the United States military with an enduring advantage through our technology strategy. The long-term strategy will be laid out in the forthcoming National Defense Science and Technology Strategy, as directed by the Fiscal Year (FY) 2022 National Defense Authorization Act (NDAA). In order to be effective, the Department must recognize both immediate challenges and be prepared to conduct long-term planning and strategies for an increasingly complex environment.

As can be seen by the Russian invasion of Ukraine, technology changes the nature of conflict and battle. Alongside the familiar tanks, ships, and aircraft, there are new hypersonic weapons and unmanned platforms that must be considered now and in future conflicts. Strategic competitors to the United States are rapidly developing state-of-the-art technologies and fielding new emerging threats. Many of these technologies, such as unmanned aerial systems, are available in the commercial market and are being proliferated worldwide. As the character of war continues to evolve, we must anticipate and be able to defend, fight, and counter any emerging threats and maintain our overmatch.

The Department performs technology horizon scanning to understand where strategic competitors are active and to understand what is state-of-the-art in the commercial sector. This information allows for better-informed decisions and allows the department to assess opportunities that can be harvested from our Nation's commercial and defense innovation ecosystem to accelerate technology adoption, and collaborate with our Allies and Partners to develop interoperable systems.

In order to build an enduring advantage for the United States, we must first build a strong foundation. This includes an expansive basic and advanced research portfolio, state-of-the-art laboratories, diverse set of testing facilities and ranges, and the best and brightest workforce. This foundation is the innovation engine that will allow us to continually develop and produce the breakthrough next-generation technology and provide disruptive capabilities expeditiously to our military. Department efforts to strengthen this foundation also rely on a strong national technological ecosystem and industrial base. Congressional efforts to support long-term U.S. leadership in advanced technologies, in particular the Creating Helpful Incentives for the Production of Semiconductors (CHIPS) for America Act and the broader Bipartisan Innovation Act, are inextricably linked to Department's ability to successfully build enduring United States advantages in applications of technology for national security. Second, we must make informed choices about which critical technologies are important to the Department. To that end, the Department has identified Critical Technology Areas (CTA) that are essential to supporting the National Defense Strategy and the mission of the joint force to build an enduring full-spectrum advantage for the United States.

## BUILDING A FOUNDATION FOR RESEARCH AND DEVELOPMENT

The United States' share of international technology innovation (as measured by patents, public and private sector funding, and number of students graduating with technical and scientific degrees) is decreasing, while the Department's need for a strong technical base is becoming increasingly urgent. We must do all that we can to maintain our advantage in science and technology (S&T), especially in an era of strategic competition. The people, processes, and infrastructure that enable the creation of innovative technologies are essential components to a strong foundation.

*Basic Research*

The Department's investments in S&T are underpinned by early-stage basic research. Investments in basic research will provide us with the seeds to harvest technology far into the future in ways that we cannot even imagine today. We have demonstrated time and again that basic research yields transformational capabilities for warfighters and often wider commercial use. Many technologies we benefit from today—lasers, the Internet, GPS, microelectronics, lithium-ion batteries, and artificial intelligence—all exist thanks to the Department's investments in basic research.

Take for instance our Vannevar Bush Faculty Fellowship (VBFF), the Department's most prestigious single-investigator award, supporting basic research with the potential for transformative impact. Professor Tresa Pollock, one of our 50 active Fellows, is working on making 3D-printed materials more resilient for battlefield use. Dr. Pollock's research team has developed and licensed a 3D-printable, high strength, defect resistant, superalloy that overcomes the issue of cracking under stress and could prove useful in hypersonics development. Since 2015, 20 percent of VBFF fellows have started new companies creating new job opportunities.

The Department's interest in basic research is not limited to only the STEM fields. The Minerva Research Initiative supports social science research that can improve the Department's basic understanding of the social, cultural, behavioral, and political forces that shape the world. In February, the Department awarded \$28.7 million in grants to 17 research projects, covering everything from team cognition for space missions to the social impacts of climate change and how best to combat propaganda distributed by the PRC.

A healthy investment in basic research is one of the Department's best tools against technological surprise. Strong open research collaborations between United States DOD funded researchers and the international science community is one of the best ways to understand the emerging state of the science. Putting barriers in the way of international collaboration does us a grave disservice.

*Applied Research and Advanced Development*

Our Applied Research and Advanced Development is supported by the Department's robust research and innovation ecosystem. R&E works hand in glove with the Service labs, DARPA, Federally Funded Research and Development Centers (FFDRCs), and 14 University Affiliated Research Centers (UARCs) across the country, defense and commercial companies, specializing in fields as varied as nanotechnology, AI and autonomy, electronic warfare, lasers, unmanned platforms, just to name a few. The Department benefits tremendously from strong partnerships across the broad technology ecosystem. The weapons systems and platforms that we have developed from precision strike to UAVs to integrated air and missile defense are highly sought after worldwide. We must accelerate the development of critical technologies to enable us to operate in a denied environment.

*Laboratory and Test Infrastructure*

The Department's labs and test infrastructure are the proving grounds of our most important discoveries. They are a foundational element in our ability to generate new ideas, test innovative new technologies, and sustain and modernize existing DOD systems. The Department's S&T laboratories engage in activities ranging from basic research to defense system acquisition support, to direct operational support of deployed warfighters. These laboratories are comprised of dozens of facilities across 22 states and employ tens of thousands of scientists and engineers, both civilian and military. The Department's laboratories execute a substantial fraction of the Department's S&T accounts, particularly in RDT&E Budget Activities (BA) 02 (Applied Research) and 03 (Advanced Technology Development), also known as BA 6.2 and BA 6.3.

To develop and test new emerging capabilities rapidly, we must modernize our laboratories and test infrastructures. One of the Department's Innovation Steering Group's primary lines of effort is to assess the state of our laboratories and test infrastructures. While existing systems continue to serve us well in testing legacy

hardware, the Department must anticipate and fund new testing and evaluation environments to support emerging technology development.

Funding lab and test infrastructure has been a recurring budget challenge for the Department and thanks are in order to Congress for the support in this area. The relative plateau of Military Construction (MILCON) budgets over the past decade has resulted in degraded facilities and a continual necessity for maintenance and repair work. This raises significant concerns about the performance, reliability, and long-term viability of the Department's lab and test infrastructure. Following congressional direction, the Department has submitted an infrastructure requirements report coincident with the President's Budget Request since 2017. The Department has taken advantage of funds for infrastructure construction, maintenance, and repair through a variety of sources and authorizations provided by Congress over the last decade, totaling approximately \$890 million. The Department looks forward to working with Congress through the development of spend plans for the use of military construction funds and on ways to address the recurring challenges with lab and test infrastructure in the future.

#### *Education, STEM and Talent Programs*

The Department is committed to cultivating the next generation of top-notch researchers, engineers, and innovators. The Department is engaged in a number of programs to promote and foster STEM education from pre-K all the way through to doctoral programs and beyond.

R&E oversees the Science, Mathematics, and Research for Transformation (SMART) Scholarship-for-Service program. In this program, undergraduate or graduate school scholars in select STEM fields receive a full tuition scholarship and internships at DOD laboratories. Upon graduation, scholars return to their respective Department facility and work there for a period equal to the amount of time they received the scholarship. In the past year, 416 SMART Scholarship recipients started work at Department laboratories or facilities.

R&E also oversees the Department's STEM Office, which recently awarded \$6 million to Arizona State University (ASU), Boston University (BU), and the University of California, Santa Barbara (UCSB) to develop K-12 biotech programs with teacher support. ASU's online curriculum is supported by their students and is targeted at reaching under-represented minorities and rural areas in Arizona. BU's program for local students includes internships and opportunities at Boston labs. UCSB is also developing a master's degree biotech program and will pilot with local minority serving community colleges.

While much of the Department's investments in STEM education are academic, the Department is also focused on exciting STEM opportunities outside of the classroom to grow our future pipeline. Since 2009, DOD STEM has sponsored teams in the For Inspiration and Recognition of Science and Technology (FIRST) K-12 robotics competition. This season, Department scientists and engineers are expected to provide more than 300,000 mentorship hours to over a 1,000 teams. The Department also held ten 5-day STEM-focused summer camps with 1,200 junior high students at laboratories, engineering centers, and academic and educational partners. The Army's Educational Outreach Program educates approximately 3,500 students in grades 5 through 12 through its Gains in the Education of Math and Science (GEMS) program. GEMS aims to interest students in STEM who might not otherwise have considered the career path.

Part of building out a talent pipeline for the next generation is ensuring that we are tapping into all of the incredible talent our Nation has to offer. That's why the Department's R&D community has long made concerted efforts to reach out to under-represented communities.

A key part of these efforts is the Department's long-standing relationship with Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs). The Department has continued to create and expand partnerships with HBCUs and MIs to stimulate research and innovation leading to the development of technologies critical to national security. Specifically, we recently established two new Centers of Excellence at HBCUs, representing a \$15 million investment. West Virginia's Morgan State University, in partnership with Johns

Hopkins and Development Command (DEVCOM) Army Research Lab, established a Center for Advanced Electro-Photonics with 2D Materials. North Carolina A&T, in partnership with Wake Forest, established a Center for Biotechnology that will develop technology for the detection and monitoring of chemical and biological threat agents. These new centers join nine other Department established centers at HBCUs and MIs.

Thank you for the authorities that allow the Department to focus efforts and investment in STEM development at HBCUs and MIs.

## CRITICAL TECHNOLOGIES TO SUPPORT THE NATIONAL DEFENSE STRATEGY

The Department's CTAs support the National Defense Strategy and address the needs of the joint force. In February, R&E identified 14 CTAs, grouped into three categories, each of which require a different approach to develop. These three categories are: Seed Areas of Emerging Opportunity (biotechnology, quantum science, Future Generation Wireless Technology (FutureG), and advanced materials), Effective Commercial Adoption Areas (Trusted AI & autonomy, integrated network systems-of-systems, microelectronics, space technology, renewable energy generation and storage, advanced computing and software, human-machine interfaces), and Defense-Specific Technologies (directed energy, hypersonics, integrated sensing and cyber). Early pioneering work in seed areas by our national and international research laboratories and world-renowned academics can revolutionize our capabilities in future conflicts. Effective commercial technology adoption areas can be pulled into the Department to rapidly enhance our capabilities. Defense Specific Technologies are areas where the DOD must take a lead in the R&D to ensure leap-ahead capabilities development.

While this testimony will not address all the CTAs in depth, I'd like to provide some recent updates.

*5G and FutureG*

To date, 5G has awarded more than 65 contracts to include over 100 companies. We are actively experimenting with seven 5G use cases to address key warfighting needs in dynamic spectrum sharing, smart warehouse and logistics, augmented reality for enhanced warfighter training and distributed command and control. The 5G/FutureG Initiative demonstrates the benefits of open 5G systems to create smart warehouses. In May 2021, we prototyped and demonstrated an Open Radio Access Network (Open RAN) in Arlington, Virginia. Immediately afterward it was set up as a testbed in a military warehouse in Albany, Georgia to enable breakthrough warehouses logistics capabilities.

*Biotechnology*

Through our Tri-Service Biotechnology for a Resilient Supply Chain (T-BRSC) program we are exploring the potential to generate high-density, high-performance fuels. Starting this year, T-BRSC will be the largest technologically advanced non-medical biotechnology program for the Department. The capability to create novel energy independence, not derived from fossil fuels, would be revolutionary.

DARPA last year demonstrated a bio-cement helicopter landing pad in 48 hours in Guam. This novel approach, when mature, may result in a significantly smaller logistics footprint and enable rapid use in austere environment.

*Microelectronics*

Seventy percent of the world's microelectronics are manufactured in Asia contributing to supply chain vulnerabilities like those we have seen during the COVID-19 pandemic. In keeping with Section 9903(b) of the FY 2021 NDAA legislation, which directs the Department to establish a National Network for Microelectronics Research and Development (NNMRD) and to expand the global leadership in microelectronics, we have led a cross functional team that has matured the Microelectronics Commons concept. We are prepared to implement the Commons in three stages. First, create "Lab-to-Fab" testing and prototyping hubs to build a network focused on maturing microelectronics technologies based on the latest research ideas. Second, we want to provide broad access to these prototyping hubs, through augmented academic facilities (i.e., a local semiconductor company or a FFRDC). Finally, we want to increase microelectronics education and training of students at local colleges and universities, creating a talent pipeline for an engineering workforce to bolster the domestic semiconductor economy.

We recognize that in order for the Microelectronics Commons to have an impact, it must be closely coupled and connected to interagency R&D, education, and workforce efforts and feed into the whole-of-government microelectronics activities. R&E actively participates in several interagency coordination efforts and DARPA co-chairs the Subcommittee for Microelectronics Leadership under the National Science and Technology Council to ensure the Department's efforts fully leverage both synergistic and complementary efforts from across the Federal Government.

*Hypersonics*

We are accelerating plans for rapid development and transition of hypersonic weapons to enable fielding of operational prototypes in quantity from land, sea, and air by the mid-2020s.

My office is engaging directly with the Joint Staff, Combatant Commands, and Military Services to ensure that the hypersonic technologies the Department is developing are integrally linked to enhancing warfighter needs.

Additionally, we are engaging with academia through the Joint Hypersonics Transition Office (JHTO) that established the University Consortium of Applied Hypersonics (UCAH) in October 2020. This office is a new way of leveraging university expertise to support the Department's most pressing science and technology hypersonics needs. The JHTO also is developing a pipeline of talented individuals who will make up the hypersonics workforce of the future.

#### WORKING FASTER AND INCREASING COLLABORATION

Innovating in a way that will maintain the Department's technical advantage depends on increasing our collaboration across the technology ecosystem and rapidly performing experimentation, testing, and fielding. Commercial technologies are evolving faster than ever before, creating potential new asymmetric threats.

In 2021, through the ISG, the Department created the Rapid Defense Experimentation Reserve (RDER), a continuous campaign of joint iterative experimentation to close joint warfighting capability gaps. We have worked closely with the Joint Staff, Combatant Commanders, the Services, with participation from our Allies and Partners, to formulate a series of joint experimentation in a highly contested environment with the intent to rapidly transition the new capabilities.

The ISG is the principal forum that advises Department leadership and drives DOD-wide strategy, policy, programmatic, cultural, and budgetary change in the areas of science, technology, technology transition, and innovation. This year, OUSD(R&E) announced the first of several sprints with the RDER program.

OUSD(R&E) funds Joint Capability Technology Demonstration (JCTD) programs that intends to meet a single specific capability shortfall defined by a Component Commander since a single Service will not provision funding to solve a joint problem. For example, R&E funded a National Capital Region's Integrated Air Defense System to extend the detection range of a specific target that met the NORTHCOM's need.

OUSD(R&E) also develops and fund Rapid Prototype Programs which demonstrates a specific capability that's not addressed by a single Service. For example, Southern Cross Integrated Flight Research Experiment (SCIFIRE) is maturing solid rocket motor for an air-breathing hypersonic cruise missile.

OUSD(R&E)'s Advanced Capabilities' Defense Modernization & Prototyping (DM&P) program focuses on funding and transitioning innovative technologies from small businesses and non-traditional performers.

#### *Collaboration with the Private Sector*

Private sector investment in technology has never been greater than it is today. However, many critical technology areas are not attractive to the private sector due to the expensive costs associated with initial investment. To ensure that the private sector pursues the technologies needed for national defense, the Department is increasing its leadership engagement and collaboration with the private sector. DIU, along with other Innovation Centers across the Department, engage with commercial industry to accelerate innovative solutions to solve military problems.

COVID-19 induced supply chain disruptions over the past few years have laid bare the importance of domestic manufacturing to our national and economic security. Catching up with manufacturing growth abroad, however, will depend on our development of leap ahead technologies like robotics, additive manufacturing, and biotechnology. The Department's Manufacturing Technology program (ManTech) is working to encourage and support this sort of innovation in the United States manufacturing ecosystem.

ManTech oversees 9 Manufacturing Innovation Institutes (MIIs). These public-private partnerships specialize in exciting fields like photonics or advanced fabrics and work to create workforce education pathways. Lightweight Innovations For Tomorrow (LIFT) has an innovative training and credentialing program that provides a curriculum to Active Duty soldiers, enabling them to earn credentials in high demand manufacturing fields. MIIs are transforming how universities and community colleges educate and how companies identify skills needed for industries of the future. These curriculum and workforce programs have helped more than 30,000 learners to date, and we were proud to welcome President Biden to the Advanced Robotics for Manufacturing (ARM) Institute in January.

Despite the Department's enormous contribution to the economy and creation of game changing technologies, it is still a challenge for a small business or startup to work with the DOD. We are committed to doing more to help small businesses and making it easier to work with the DOD and to bridge the valley-of-death.

The Department's Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) programs allow the DOD to support innovative small businesses to develop breakthrough technologies and capabilities that we need.

We have upgraded our SBIR/STTR Innovation Portal, making it easier to engage and participate with the Department. We are engaging with the small business community to understand the challenges that they face and are working to systemically tear down obstacles.

We are also focused on improving how the Department engages with the private sector to ensure that defense needs will be addressed by dual-use technologies. Increasing private sector investments in technology is advantageous for the Department so that we can purchase that technology commercially as it becomes available, supporting both defense and commercial needs. The Department is exploring additional ways to take a more active role in the commercial technology sector to ensure that defense objectives will be addressed.

#### COLLABORATION WITH ALLIES AND PARTNERS

Collaboration with Allies and Partners may significantly increase the speed in which we can develop interoperable technologies benefiting both nations. Many existing multilateral and bilateral agreements serve as a platform for increased collaboration, such as The Technical Cooperation Program (TTCP) with our "Five Eyes" Allies (Australia, Canada, New Zealand, United Kingdom, and United States), and the North Atlantic Treaty Organization (NATO) Science and Technology Organization. We are also looking to expand international R&D defense collaboration with other Allies and Partners based on shared defense interests and technology priorities.

The Department supports NATO's efforts to leverage centers of innovation to meet NATO's operational requirements. NATO's Defense Innovation Accelerator for the North Atlantic (DIANA) seeks to accelerate the development of dual-use emerging and disruptive technology through innovation. DIANA's focus on multi-sector participation will highlight innovative entrepreneurs from small start-ups, mid-sized companies and academic institutions that can solve critical defense and security challenges.

The AUKUS (Australia, United Kingdom, United States) defense pact is a new area of opportunity that is already showing success. Last year, President Biden, along with Prime Minister Morrison and Prime Minister Johnson, announced the creation of an enhanced trilateral security partnership among our three nations. To meet the challenges of the twenty-first century, AUKUS will fortify longstanding bilateral ties while strengthening the security and defense interests in the Indo-Pacific region by evolving advanced capabilities collectively.

Working closely with our Allies and Partners, the Foreign Comparative Testing (FCT) Program enhances our Nation's military's capabilities. FCT is locating, assessing, and fielding mature foreign developed technology products to meet emerging defense requirements. For example, our soldiers utilize a palm-sized unmanned aerial vehicle (UAV) from Norway that enables enhanced battlefield surveillance and reconnaissance, a long-range missile from Israel that's improving standoff lethality and survivability against enemy air defense systems. Our sailors will utilize a mobile coastal defense rocket system from the Republic of Korea, providing a counter swarm capability against maritime attack craft.

#### CONCLUSION

In order to provide the United States with the long-term capability to develop and rapidly field the most innovative technologies to maintain overmatch, it is essential to have a solid R&D foundation consisting of a broad base of basic and applied research, rapid prototyping capability, continuous joint experimentation and testing, state-of-the-art lab and test infrastructure, rapid ability to transition to fielding, and a highly-talented workforce. The objective of increased collaboration across our technology ecosystem is to accelerate the timeline in which emerging technologies can revolutionize our warfighting capabilities. Implementing these concepts through the National Defense Science and Technology strategy will build a technological enduring advantage for the United States Military. Thank you for the invitation to testify in your Committee, and I look forward to the discussion.

Senator KELLY. Thank you, Secretary Shyu. Dr. Tompkins?

**STATEMENT OF DR. STEFANIE TOMPKINS, DIRECTOR,  
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**

Dr. TOMPKINS. Thank you, Chairman Kelly and Members of the Subcommittee. I echo Secretary Shyu's thanks for the opportunity to testify today, and I thank you very much for the committee's strong support of DARPA over many years.

It is great to be here with my colleagues. As you know, our organizations work together constantly to advance national security, and we are part of a really extraordinary science and technology ecosystem that extends far beyond just the Department of Defense.

Within that ecosystem, DARPA has a unique role. Our mission is to create technological surprise. We do this by making pivotal investments in technologies that we believe have the potential to completely transform national security. We have been delivering on the mission for over 60 years. We brought to the DOD, and to the Nation, game-changers like precision-guided munitions, and the Javelin missile, by the way, stealth aircraft, unmanned aerial vehicles (UAVs), the internet, miniaturized GPS receivers, and as you mentioned, Mr. Chairman, most recently, mRNA vaccines.

We are extraordinarily lucky in that we are able to work extremely quickly. We do not just tolerate but we embrace risk, and we constantly seek what we call DARPA-scale impact. One of our program managers once joked, "If you didn't invent the internet, you only get a B." Now I should add that that program manager was working on mRNA vaccines at the time, so I think in retrospect he probably earned an A.

But that is the past, and so you should ask what we are working on today. Imagine a world where a soldier's basic needs, things like food, water, fuel, or medicine are made right on the spot from waste material, say from plastic, or even just from the air, completely independent of vulnerable supply chains. Imagine a world where both our electronics and our software are completely secure by design and thus unhackable. Imagine a world in which all of our military systems, which today have a lot of trouble interoperating, can seamlessly communicate and work together to provide inherently joint capabilities to our military commanders. Those are some of the futures that DARPA seeks to make real.

We are also working to transition technology faster than ever. It is a very dynamic world, and as we have all discussed and observed, quite volatile. So we are creating new ways to do testing, faster than real time and with the assistance of artificial intelligence (AI), to explore thousands of use cases and missions.

We are transitioning technology not just through programs of record but through new commercialization initiatives, through new partnerships with the Combatant Commands (COCOMs), or with organizations such as DIU or other parts of the R&E enterprise, or through rapid DevOp cycles in order to get software directly into the hands of users.

In addition to the futuristic versions that I shared a minute ago, we also work closely with the military services to de-risk nearer-term technology. For example, as has been very recently reported in the press, DARPA, in partnership with the U.S. Air Force, recently completed a second successful flight test of our Hypersonic-Air breathing Concept, known as HAWC. This test set the U.S.

record for scramjet endurance, and we believe it is an inflection point on a path to reclaiming U.S. leadership in hypersonic weapons.

In my written testimony you will see many more examples of DARPA portfolios and programs. I ask you please to remember that some of those will fail. If they do not, it means we are not trying hard enough and we are not taking enough risk. But some of those will succeed, and in doing so may fundamentally transform our nation and strengthen our national security in ways that we can only begin to imagine.

I thank you again for your support to DARPA over many, many years, and I look forward to working with you and others in Congress to ensure the security and resilience of our great nation, and as Secretary Shyu mentioned, looking forward to answering your questions.

[The prepared statement of Dr. Stefanie Tompkins follows:]

PREPARED STATEMENT BY DR. STEFANIE TOMPKINS

Chairman Kelly, Ranking Member Ernst and Members of the Subcommittee, thank you for the opportunity to testify before you today. I am Stefanie Tompkins, Director of the Defense Advanced Research Projects Agency, DARPA. It is a pleasure to be here with my colleagues, Ms. Heidi Shyu, from the office of the Undersecretary for Research and Engineering (USD(R&E)), and Mr. Michael Brown, Director of the Defense Innovation Unit (DIU). Our organizations work together every day to advance national security through new technology. DARPA plays a particular role in both the DOD and the broader U.S. technology ecosystem. That role is to anticipate, create, and demonstrate breakthrough technologies that are outside and beyond conventional approaches—technologies that hold the potential for extraordinary advances in national security capabilities.

For more than 60 years, DARPA has held to a singular and enduring mission: to create technological surprise. We do this by making pivotal investments in breakthrough technologies for national security. Working with innovators inside and outside government, DARPA has repeatedly delivered on our mission, transforming revolutionary concepts and seeming impossibilities into practical capabilities. The results have included game-changing military capabilities like precision weapons, stealth technology, and unmanned aerial vehicles, as well as icons of modern civilian society such as the internet, automated voice recognition and language translation, miniaturized GPS receivers, and, just a decade ago, mRNA-based vaccines. Today, DARPA's role has never been more vital. From being front and center in our Nation's fight against the COVID-19 virus, to defensive as well as offensive hypersonics technologies, state of-the-art artificial intelligence, quantum technologies, and directed energy solutions, DARPA is delivering on our most pressing security needs.

DARPA creates and executes programs that rely on and inspire an innovation ecosystem of academic, industry, and government partners. Efforts to strengthen the U.S. technological ecosystem as a whole, such as the Bipartisan Innovation Act, would therefore significantly enable DARPA's efforts to provide game-changing technical solutions. We work with national security leaders and the Nation's military services to understand today's hardest challenges and anticipate tomorrow's, and demonstrate transformational technology solutions for both.

We work quickly, embrace risk, and seek what we call "DARPA-scale impact". One of our program managers once joked, "if you didn't invent the internet, you get a B". In recent years, with the democratization and acceleration of technological advances around the world, we have increased our emphasis on rapid prototyping and on faster and lower-cost methods of designing, building, and testing technology not just in controlled settings but in the complex, dynamic, messy real-world environments in which they must ultimately succeed. Today, I will focus my testimony on examples of DARPA portfolios and programs in various stages of development and transition. Please remember: some of these may fail. But some will succeed, and in doing so may fundamentally transform our ability to defend the homeland, deter adversaries, increase global stability, and lay the foundations for continued technological surprise.



## “AI NEXT” CAMPAIGN

DARPA has been a leader in artificial intelligence since the 1960s. The agency played key roles in realizing the first and second waves of AI (first rule-based, then statistical-learning-based), and now we are working to realize the third wave, which can be described as contextual adaptation. To better define a path forward, DARPA announced in September 2018 a multi-year investment of over \$2 billion in new and existing programs called the “AI Next” campaign.

Currently, DARPA is pursuing more than 39 programs that are exploring ways to advance the state-of-the-art in AI, pushing towards third wave contextual reasoning capabilities. In addition, more than 60 active programs are applying AI in some capacity, from sharing electromagnetic spectrum bandwidth to detecting and patching cyber vulnerabilities.

Under the AI Next campaign, key areas being explored include improving the robustness and reliability of AI systems; enhancing the security and resiliency of machine learning and AI technologies; reducing power, data, and performance inefficiencies; and pioneering the next generation of AI algorithms and applications, such as “explainability” and commonsense reasoning.

DARPA also has a quick-turn funding mechanism called Artificial Intelligence Exploration (AIE) that allows the agency to test the feasibility of AI concepts by rapidly developing prototypes. AIE opportunities are released on a rolling basis from across DARPA’s portfolio, providing awards within 90 days of up to \$1 million each for 18-month periods of performance. During these periods of performance, we investigate very high-risk, high-reward topics to assess feasibility and clarify whether the area is ready for increased investment. To date, we have made 244 contract awards for more than 37 AIE topics, and launched at least 2 significant research investments based on the AIE research results.

## APPLYING AI (EXAMPLE): CBRNE DETECTION

A representative example of our AI Next campaign is the SIGMA+ program, which seeks to alert authorities when there is a chemical, biological, radiological, nuclear, or explosive (CBRNE) attack in a US city or on a military base. Last year, in collaboration with the Indianapolis Metropolitan Police Department (IMPD), we concluded a three-month pilot study focused on early detection and interdiction of CBRNE threats. For the pilot, researchers integrated highly sensitive chemical and biological sensors into several IMPD vehicles and characterized the real-world environmental background data over a large part of the Indianapolis metropolitan region. Researchers then used AI-supported algorithms to detect chemical simulants against that background.

Knowing the naturally occurring chemical and biological backgrounds in an area allows customization of both sensors and algorithms to minimize false positives and maximize detections of threats. During the Indianapolis pilot study, nuisance alarms were suppressed by 75%.

The Indianapolis pilot study and field testing marked the first time DARPA was able to demonstrate comprehensive SIGMA+ sensor technology in a law-enforcement vehicle, including air sampling, power, and a user interface that provided real-time analysis of potential threats via a tablet. The ultimate goal is to outfit a citywide fleet of law enforcement and other public service vehicles to enable a continuously refreshed mobile network that can detect CBRN threats with low false-alarm rates across a city and region. Next steps for SIGMA+ include testing in other metropolitan regions and developing operational procedures to integrate sensors into real-world use.

## ADVANCING AI (EXAMPLE): MACHINE LEARNING WITH LIMITED DATA

Much has been written about how the commercial world has harvested and created large sets of labeled data for training machine learning (ML) models. Unfortunately, when we try to use these models on DOD and Intelligence Community alert problems, they fail. This is because military-relevant data collections are often degraded and noisy—we are collecting images and audio non-cooperatively, we are processing seized/degraded media, or our sensors are different than commercial sensors. DARPA’s Learning With Less Labeling program is developing new learning algorithms that require much less information to train or update ML models with increased accuracy.

The approach we take in Learning with Less Labeling (LwLL) is to generalize the machine learning objective. It turns out that many machine learning algorithms boil down to an optimization problem. The research goal is to use a million times fewer

images than today's standard practice to train a system, and require roughly 100 labeled examples to adapt a system instead of the millions needed today.

In the context of identifying objects in images, LwLL researchers have already demonstrated and benchmarked, using real-world examples, a new technique that requires 1000x less labeled data than conventional ML with only 10% degradation in accuracy. This early breakthrough is promising and is already being shared with DOD transition partners, while the program continues to advance towards its ultimate goal of demonstrating a 1,000,000x reduction in labeled data required.

#### ASSAULT BREAKER II

Modern warfare is becoming less about singular platform and weapon capabilities, and more about combinations of systems that can be rapidly developed and composed into more effective warfighting constructs. DARPA's Assault Breaker II (ABII) initiative seeks to change fundamentally the way the military thinks about designing, buying, and deploying future systems.

First, the ABII program addresses several challenges posed by our strategic competitors. Patterned after the original Assault Breaker program in the late 1970's, a memorandum of agreement was signed by DARPA and the vice chiefs of all five Services to establish a joint service team creating technology solutions for these critical challenges. Interacting closely with the intelligence, military operator, and technology communities, the team's first objective is to design warfighting operational constructs based on new and emerging technologies and capabilities.

The program's second objective is to develop an advanced modeling and simulation environment to support analysis of true cross-domain, cross-service warfighting constructs. Finally, the program is tying modeling and simulation into an interactive experiment environment to support exploration of highly complex, interdependent approaches that characterize the future of warfighting.

ABII seeks to organize this evolution in warfighting and act as a conduit both to communicate technology solutions to the services as well as articulate critical challenges to the technology development community in a manner where they can appreciate the larger picture. ABII will serve as a technical baseline for multi-domain operations moving forward.

#### ELECTRONICS RESURGENCE INITIATIVE

In June 2017, DARPA announced the Electronics Resurgence Initiative (ERI) as a bold response to several technical and economic trends in the microelectronics sector. Among these trends, the rapid increase in the cost and complexity of advanced microelectronics design and manufacture is challenging a half-century of progress under Moore's Law, which holds that the number of transistors per silicon chip doubles every year. Meanwhile, non-market foreign forces are working to shift the electronics innovation engine overseas, while cost-driven foundry consolidation has limited DOD access to leading-edge electronics, challenging U.S. economic and security advantages. Moreover, highly publicized challenges to the Nation's digital backbone are fostering a new appreciation for electronics security—a longtime defense concern.

Building on the tradition of other successful government-industry partnerships, ERI is forging forward-looking collaborations among the commercial electronics community, defense industrial base, university researchers, and the DOD to address these challenges. There is significant historical precedent to suggest the viability of this approach, as each wave of modern electronics development has benefited from the combination of defense-funded academic research and commercial sector investment.

Given today's cost, complexity, and security challenges, it is critical that the nation collaboratively innovate on the next generation of electronics advancement. DARPA is advancing research in four key areas—3D heterogeneous integration, new materials and devices, specialized functions, and design and security—each of which have been central to ERI since its inception. Leveraging 3D heterogeneous integration, the next wave should support continuing electronics progress despite challenges to traditional silicon scaling. This integration will enable innovators both to add new materials and devices to the silicon foundation and create specialized functions precisely designed to meet the diverse needs of the commercial and defense sectors. To manage the complexity of working in three dimensions, the next wave will also demand new architectures and design tools that address rising design costs, enable rapid system upgrades, and make security integration a primary design concern.

A major component of ERI is the JUMP Initiative. In late December 2021, DARPA announced its participation in a new public-private partnership with the

Semiconductor Research Corporation (SRC) and a consortium of companies in the commercial semiconductor industry and the defense industrial base called the Joint University Microelectronics Program 2.0 (JUMP 2.0). The program supports high-risk, high-payoff university research that addresses existing and emerging challenges in information and communication technologies. JUMP 2.0 builds off an earlier iteration of the SRC-led collaboration that was formed in 2018 to support university research centers focused on maintaining U.S. microelectronics innovation. The targeted efforts of ERI play a critical role in the U.S. microelectronics ecosystem and support the whole-of-government efforts underway to ensure continued leadership in this important area.

#### CYBER

In addition to addressing threats in the physical world, DARPA is also intensely focused on threats in the virtual world. To further this area of research, last year, DARPA conducted its first bug bounty program—the Finding Exploits to Thwart Tampering (FETT) Bug Bounty—to evaluate hardware protections in development on the System Security Integration Through Hardware and firmware (SSITH) program. SSITH explored hardware security architectures and tools that protect electronic systems against common classes of hardware vulnerabilities exploited through software, with the goal of breaking the endless cycle of software patch-and-pray.

Through FETT, hundreds of cybersecurity researchers and reverse engineers had virtual access to secure SSITH processors in order to detect weaknesses and vulnerabilities. Key to this effort was the development of a scalable, virtualized platform for remotely testing and evaluating the processor prototypes. The platform is a first-of-its-kind infrastructure that provides a means of virtually crowdsourcing the analysis of future processor technologies.

After rigorous testing and evaluation, researchers have proven that SSITH concepts provide robust hardware safeguards against known weakness enumeration (CWE) classes of hardware vulnerabilities. The program is now focused on transitioning and converting the proven concepts from lab discoveries to practical application. For instance, SSITH successfully worked with Arm Ltd to incorporate SSITH protections into Arm’s microcontroller-class and high-performance processor product lines. Over 20 billion Arm processors are made each year, and are used widely within DOD weapon systems.

#### LONG RANGE EFFECTS

The ability to field hypersonic systems ranks high on the DOD’s list of priority technologies, due in part to the pace of research by peer adversaries. Hypersonic flight at velocities of more than five times the speed of sound offers major strategic advantages, especially for conducting military operations from longer ranges, with shorter response times, and enhanced effectiveness compared to current military systems.

Last year, DARPA, in partnership with the U.S. Air Force, completed a free flight test of its Hypersonic Air-breathing Weapon Concept (HAWC). The missile was released from an aircraft seconds before its scramjet (supersonic combustion ramjet) engine kicked on.

The HAWC vehicle operates best in the lower atmosphere, where speed and maneuverability make it difficult to detect in a timely way. It could strike targets much more quickly than subsonic missiles and has significant kinetic energy even without high explosives. The test brings us one step closer to transitioning HAWC to a program of record that offers next generation capability to the U.S. military.

#### DISTRIBUTED COMPLEX SYSTEMS

For several years now, DARPA has been spearheading the “Mosaic” construct of future warfare. The Mosaic concept posits that using less expensive systems brought together on demand as the conflict unfolds could facilitate the creation of “effects webs,” enabling diverse, agile applications—from a kinetic engagement in a remote desert setting, to multiple small strike teams operating in a bustling megacity, or an information operation to counter an adversary spreading false information in a population threatening friendly forces and strategic objectives. Mosaics, therefore, can be rapidly tailored to accommodate available resources, adapt to dynamic threats, and be resilient to losses and attrition.

One program resulting from the Mosaic concept is STITCHES, or System of Systems (SoS) Technology Integration Tool Chain for Heterogeneous Electronic Systems. STITCHES is an open-source approach to allowing interoperability between systems that have complimentary functions but were not designed to be imple-

mented together. Recently, the DOD evaluated STITCHES, determining it enables Joint All Domain Command and Control (JADC2) interoperability. By pushing message translation to the edge, joint interoperability could be achieved via a federated point-to-point solution that scales linearly vice the traditional quadratic complexity scaling. As the number of systems and domains increases, this linear scaling offers a dramatic decrease in complexity and cost while increasing speed of interpretation and adaptability. STITCHES enables not just data translation but also in-line synchronization, and functions that are traditionally achieved by changing system software or physical gateways.

#### WARFIGHTER PROTECTION AND PERFORMANCE

Spinal cord injury disrupts the connection between brain and body, causing devastating loss of physiological function to the wounded warfighter. In addition to paralysis, servicemembers living with these injuries exhibit increased long-term morbidity due to factors such as respiratory and cardiovascular complications. Bridging the Gap Plus (BG+), a new DARPA program that combines neurotechnology, artificial intelligence, and biological sensors, opens the possibility of overcoming the worst effects of spinal cord injuries by promoting healing at the wound site and interfacing with the nervous system at points around the body to restore natural functions such as breathing, bowel and bladder control, movement, touch, and proprioception that can be lost when the spinal cord is damaged.

BG+ encompasses two research thrusts aimed at developing and integrating technologies for injury stabilization, regenerative therapy, and functional restoration to support patients during all phases of spinal cord injury—acute, sub-acute, and chronic. DARPA's focus is on improving healing outcomes during the acute and sub-acute phases of injury (approximately the first 2 days to two weeks after injury), and on restoring lost function in the chronic phase of injury.

DARPA created BG+ as a five-year program, scheduled to conclude with clinical demonstrations in human patients. Just this February, BG+ researchers demonstrated a minimally invasive approach to restore bowel function in cats, which avoids the pitfalls of traditional surgical approaches that can leave patients with irreversible nerve damage. This functionality will be incorporated into a user-controlled, integrated visceral function restoration system to give veterans and others with paralysis a useable long-term solution.

#### GRAY WARFARE

The U.S. is engaged with its adversaries in an asymmetric, continual, war of weaponized influence narratives. Adversaries exploit misinformation delivered via influence messaging: blogs, tweets, and other online multimedia content. Analysts require effective tools for continual sensemaking of the vast, noisy, adaptive information environment to identify geopolitical influence campaigns.

Today, detection and sensemaking of adversary influence campaigns is largely manual and ad hoc. With current tools, it is difficult to connect messages over time and across multiple platforms to track evolving campaigns, and analysts must manually sift through a high volume of messages to find those with relevant influence agenda and then gauge which ones are gaining traction and with whom.

The INCAS program began in 2021 to address these challenges. If successful, INCAS will provide analysts with the ability to detect, characterize, and track geopolitical influence campaigns across multiple languages and platforms with confidence. INCAS addresses the increasingly complex world of information warfare, building upon and adding to previous DARPA successes with our programs in Media Forensics and Semantic Forensics, which detect manipulated imagery and information.

#### CLIMATE AND ENVIRONMENT

Sea level rise and wave-induced flooding during storm events threaten sustainability of the more than 1,700 Department of Defense (DOD) managed military installations in coastal areas worldwide. Despite previous efforts to implement storm mitigation solutions, damage due to storm surge and flooding continues to impact military infrastructure. Current DOD coastal protection measures, including bulkhead and coastal seawalls, may reflect wave energy, exacerbate flooding, create downstream sediment loss, and restrict water exchange. To protect DOD personnel and infrastructure, DARPA has established the Reefense program, which aims to develop novel hybrid biological and engineered reef-mimicking structures to mitigate wave and storm damage and reduce the ecological impact of current coastal protection measures.

As part of the Reefense program, custom wave-attenuating base structures will promote coral or oyster settlement and growth, which will enable the structures to be self-sustaining and address the infrastructure-related impacts of sea level rise over time. Program performers are employing recent innovations in materials science, hydrodynamic modeling, and adaptive biology to optimize these structures for responding to a changing environment.

Reefense takes the novel approach of integrating structural engineering, reef health, and adaptive biology to create reef-like ecological systems. These structures will help significantly reduce infrastructure maintenance costs, promote ecosystem health, and strengthen DOD's ability to maintain its infrastructure and military readiness.

#### MODELING, SIMULATION, AND EXPERIMENTATION

Following recent successful experimentation with Marines at Camp Lejeune, North Carolina, DARPA's Prototype Resilient Operations Testbed for Expeditionary Urban Scenarios (PROTEUS) program will transition to the Marine Corps Warfighting Laboratory (MCWL) in Quantico, Virginia.

PROTEUS comprises a suite of visual software training and experimentation tools that enables Marines from squad to battalion level to explore and develop novel multidomain fighting concepts. The tools allow Marines to integrate emerging capabilities and learn how to effectively employ them in realistic expeditionary combat scenarios.

DARPA launched PROTEUS in 2017 and recently completed a five-day capstone demonstration with 1st Battalion, 2nd Marines at Camp Lejeune, where Marines rapidly explored and assessed future infantry battalion task organizations, force packages, and tactics. PROTEUS provided unique insights in support of the Marine Corps' Force Design 2030, the Service's plan for organizing, training, and equipping Marines for future challenges.

Using the PROTEUS software, Marines were able to visualize and manipulate their electromagnetic footprint, apply logistics support automation, and obtain quantitative analytics on the effectiveness of force packages and tactics in real time. PROTEUS brings the power of multi-domain force package and CONOPS (concept of operations) development to the platoon, company, and battalion.

#### TRANSITION AND BUSINESS/COUNTERING FOREIGN INFLUENCE

Over the past two years, DARPA's Embedded Entrepreneurship Initiative (EEI) has helped more than 50 pre-seed stage research teams raise over \$275 million in U.S. investment, spin out a dozen new companies, establish numerous joint development agreements with corporate partners, and commission multiple manufacturing facilities. In early 2021, DARPA launched an expansion of EEI with the goal of accelerating 150 DARPA-backed technologies out of the lab and into products that promise to fundamentally change the way we live, work, and fight. EEI augments technical research teams with critical entrepreneurial expertise, top-tier commercialization mentors, and connections to investors, effectively countering aggressive adversary-nation investors by building stronger companies that have the ability to attract U.S. capital.

EEI provides catalytic funding, mentorship, and investor and corporate connections for select DARPA researchers. Resources include: an average of \$250,000 in non-dilutive funding to hire a seasoned entrepreneur or business executive for one to two years with the goal of developing a robust go-to-market strategy for both defense and commercial markets; dedicated commercialization mentors with extensive private sector experience; and engagement with DARPA's private sector Transition Working Group comprising over 100 top-tier U.S. investors and corporations key to scaling and supply chain development.

DARPA-funded scientists and engineers are an invaluable resource for national competitiveness. Supporting these researchers with tailored business expertise to advance their innovations for public and military use is critical to obtaining the full benefit from taxpayer funded R&D investments.

#### FOUNDATIONS OF TECHNOLOGICAL SURPRISE

One of the classic models of technology development begins with basic or early-stage applied research that uncovers a new principle or phenomenon, which innovators then apply and develop into a new capability. This model cannot account for the origin of all of the technologies DARPA has had a hand in, but it applies to many of them. DARPA's job is to change what's possible—to do the fundamental research, the proof of principle, and the early stages of technology development that take "impossible" ideas through "implausible" and then to, surprisingly, "possible"

or even “likely.” No other DOD agency has the mission of working on projects with such a high possibility of producing truly revolutionary new capabilities—or such a high possibility of failure.

A particularly timely and relevant example has to do with quantum computing. Several DARPA programs explore aspects of quantum computation to determine which approach offers the most promise for substantial practical advantage. Of note, the Quantum Benchmarking (QB) program seeks to bring rigor to the fledgling quantum computing marketplace with the introduction of insightful benchmarking. There is much potential that quantum computing may make possible—in diverse markets such as pharmaceuticals, battery catalysis, and machine learning—but it is also possible that there is limited value of any sort in quantum computing beyond the commonly discussed application of unlocking encrypted data.

QB was started in 2021 with the goal of developing key quantum computing metrics, making those metrics testable, and estimating the required quantum and classical resources needed to reach critical performance thresholds. Coming up with effective metrics for large quantum computers is no simple task. Current quantum computing research is heavily siloed in companies and institutions, who often keep their work confidential, and existing metrics (such as the number of interacting qubits in a system) may not be relevant to actual computing performance on many applications. If successful, QB will accelerate the development of quantum computing across multiple domains, or illuminate its lack of utility in those same domains.

#### CONCLUSION

From DARPA’s perspective, the technological future is enormously attractive, bright with opportunities, but also fraught with the potential for technological surprise from our adversaries. For more than 60 years, the men and women of DARPA have taken very seriously our unique mission to prevent such surprises by creating our own.

One year after returning to DARPA, it is clear to me that we are stronger and more committed to that mission than ever. I look forward to working with the members of this subcommittee and others in the Legislative and Executive branches to ensure that the United States maintains its lead in the investigation and development of powerful technologies, in addition to their safe and responsible application in support of a more stable, secure, and sustainable world.

Senator KELLY. Thank you, Dr. Tompkins. Mr. Brown.

#### STATEMENT OF MICHAEL BROWN, DIRECTOR, DEFENSE INNOVATION UNIT

Mr. BROWN. Chairman Kelly and Members of this Subcommittee, thank you for inviting my colleagues and me to speak on behalf of innovation at the Department. Today I would like to speak to one of the most urgent challenges to bolster our nation’s defense—speeding the adoption of commercial technology to our warfighters, which Secretary Shyu talked to.

In an era where the Chinese Government has stolen plans for our weapons and studied our way of fighting, advances in commercial technology offer a way to achieve surprise rapidly. Under Secretary Shyu recently released a list of 14 critical technologies for national security. Eleven of the 14, 80 percent, are commercial. Not having an effective approach to adopting commercial technology is a glaring weakness in modernizing DOD.

Since 2015, DIU has transitioned 43 commercial solutions to service partners, 8 in the first half of this fiscal year alone. As one example, DIU successfully prototyped synthetic aperture radar satellites which can see through clouds and at night, and provided the world imagery of Russian forces in and around Ukraine. This enabled us to predict the invasion and prove undeniably what was happening without revealing classified sources. Today, the National

Reconnaissance Office (NRO) is providing this capability as part of security assistance to Ukraine.

These 43 transitions encourage more DOD mission partners to initiate more modernization projects. In the last fiscal year, DIU started a record 37 projects, double our historical average. Additionally, last year companies competing for DIU contracts increased 40 percent and represented 47 states, the District of Columbia, and 17 countries. In total, DIU has introduced 100 new vendors to DOD.

DIU's successes, however, are less than 1 percent of DOD's procurement budget. In part, this is because commercial technologies are different than defense technologies. First, they are supplied in massive unit volumes, sometimes in the millions, often led by consumers. Second, commercial technologies evolve at faster speeds than defense technologies, refreshed in 12- to 18-month cycles. Third, commercial technologies are not service specific, so we often do not know where to buy them. Lastly, we do not control the spread of commercial technologies. Dangerously, they are available through our adversaries as soon as they are available to us. No wonder, then, that we need a different way to assess and buy these commercial technologies.

So DOD must become what I call a fast follower to gain rapid access to technologies and maintain at least technological parity with adversaries. For this, DOD requires a rethink of the three elements of how we bring capabilities to the Department. Number one, requirements, where commercial technology negates the need for detailed specifications. Number two, acquisition, where DIU's use of non-consortium Other Transaction Authorities (OTAs) in a largely commercial process we invented called Commercial Solutions Opening (CSO) can be more broadly applied throughout the Department. Number three, budgeting, where new commercial solutions enter the market faster than our 2- to 3-year budget cycle.

Despite acquisition reform there has been almost no reform of the requirements or budgeting processes. Here are my recommendations.

First, establish dedicated organizations or homes for each of the commercial technologies, which can focus our expertise and which are not and do not need to be service-specific. Paired with a stable budget, this becomes a capability of record, not a program of record, where the need for the capability is ongoing. DOD can then assess vendors on a more continuous basis and refresh with a frequency that matches commercial cycles. In doing so, DOD can furnish these capabilities to warfighters in a year rather than in a decade.

Second, eliminate the requirements process for commercial technologies, replacing it with a rapid validation of needs. We do not need to develop detailed requirements for products the commercial market already builds. In fact, detailed requirements limit the creative problem-solving of companies and limit the number of companies competing.

Third, apply the best practices of commercial procurement that we have learned, more widely apply consortia OTAs and CSOs, thereby maximizing competition while minimizing opportunity costs for vendors to participate. Importantly, if a vendor success-

fully prototypes a solution there is no required recompile and DOD can scale the solution immediately, eliminating one of the valleys of death caused by waiting for the budget cycle to catch up.

Finally, source commercial technologies from allies, and sell proven solutions to allied militaries, which present excellent export opportunities for U.S. companies. The easiest form of collaboration with allies is with commercial technology, which is unclassified and enables interoperability.

At DOD we continue in a business-as-usual fashion at our peril. We must reform requirements and budgeting while more broadly adopting OTAs to better assess and fuel commercial technologies. I ask Congress to allow for more flexibility in the appropriations process beyond programs to budget for capabilities like small drones or satellite imagery, which we know we will need for decades to come. Maintaining our military's technological superiority requires us not only to develop defense technologies like hypersonics but of equal importance, fast follow the innovations of our vibrant commercial technology sector. There is a reason the U.S. innovation ecosystem is the envy of the world, and we need to make this the envy of the military.

Senators, thank you very much for your time today, and with my colleagues I look forward to answering your questions.

[The prepared statement of Mr. Brown follows:]

#### PREPARED STATEMENT BY MICHAEL BROWN

Chairman Kelly, Ranking Member Ernst, and distinguished Members of this Subcommittee, thank you for inviting me to testify on behalf of the Defense Innovation Unit (DIU). I'm Michael Brown, and I have been Director of DIU since September 2018. I appreciate the opportunity to speak about the urgent necessity of accelerating innovation—and specifically commercial technology—for our warfighters.

#### INTRODUCTION

The Department now acknowledges the People's Republic of China (PRC) as a pacing challenge. In previous eras, the United States maintained decisive military advantage over its adversaries due, in large part, to superior technology capability. The Department of Defense (DOD) harnessed technical resources across the spectrum of American industry, national laboratories, and universities and used its purchasing power to shape technical specifications and standards for resulting technologies. This strategy ultimately conferred the U.S. military with superior advantages in the first offset (nuclear weapons and nuclear deterrence technology) and second offset (night vision, laser-guided bombs, stealth and jamming technologies as well as space-based military communications and navigation).

The threat matrix the United States faces today is significantly more diverse and acute than in previous eras. While the DOD continues to develop offensive and defensive capabilities around nuclear weapons and conventional military platforms, as the NDS highlights, dual-use emerging technologies will change the character of warfare going forward. The private sector is pioneering the development of most of these advanced dual-use technologies by leveraging software, open source data sets, and advanced processing speed—all primarily for commercial use. Many technologies that were previously only available to nation-states have now become democratized and available to any consumer or adversary.

#### BACKGROUND

I came to the Defense Innovation Unit (then Defense Innovation Unit Experimental) nearly 6 years ago as a Presidential Innovation Fellow charged with understanding the character, quantity, and quality of PRC investments in the U.S. technology ecosystem. At that time, largely ungoverned by the Committee on Foreign Investment in the United States (CFIUS) or existing export controls—investments into U.S. startups were fair game for adversarial nation-states. In fact, we discovered that the PRC is pursuing a deliberate and robust technology transfer strategy,



which still includes investing in early stage dual-use technologies, gathering intellectual property, and strategically identifying and poaching talent from U.S. companies and academic institutions. The key finding of our work was that PRC-backed investment firms in 2016–2018 were investing at a level approaching 20 percent of all U.S. venture-backed deals. By sponsoring investments in emerging technologies—from artificial intelligence and machine learning to additive manufacturing, biotechnology, and quantum sciences—the PRC is learning at the same pace, if not faster, than the U.S. national security apparatus. From an economic competitiveness perspective, this is obviously worrying; however, there are now well documented reports<sup>1</sup> pointing to an even more troubling fact: the People's Liberation Army (PLA) is rapidly integrating dual-use technologies developed in the commercial sector into warfighting concepts to achieve asymmetric advantage over the United States.

In response, the United States' first actions were defensive—to close loopholes and strengthen our defenses. Congress made that possible by passing the Foreign Investment Risk Review Modernization Act (FIRRMA) and the Export Control Reform Act (ECRA) in 2018. Even implementation of these new authorities has not fully prevented the illegal transfer of critical technologies. The United States must continue whole-of-government efforts to protect critical U.S. technology, know-how, and talent, and to raise awareness regarding the PRC's lever aging of foreign investment to enable its military capabilities.

My focus today is to discuss the progress we are making on offensive in running faster. Overarching and foundational investments, such as the CHIPS Act as well as the broader Bipartisan Innovation Act, are necessary to maintain long-term U.S. leadership in the technologies that will be the drivers of innovation in the coming decades. However, by themselves these measures will also be insufficient to ensure the United States can translate technological leadership into national security advantage. *The Department of Defense (DOD) needs to outpace our adversaries in identifying, integrating, and deploying commercial technologies into current warfighting concepts and creating new concepts.* In an era where the PRC has stolen plans for our exquisite weapons platforms and carefully studied our way of fighting, advances in commercial technology offer a unique opportunity to achieve surprise rapidly. Despite its importance, DOD does not currently have a systematic or effective approach to rapidly access and leverage commercial technologies at scale. My first boss at DIU, Michael Griffin, the first Under Secretary for Research and Engineering, developed a list of ten critical technologies for national security: eight of those ten were commercial. My current boss, Heidi Shyu, just released her own list of 14 critical technologies for national security: 11 of the 14 technologies are commercial. *Not having an effective approach to rapidly adopt commercial technology is a glaring weakness in modernizing DOD.* Technologies such as advanced communications, AI software, small drones, synthetic aperture radar (SAR) satellite imagery and many others can be rapidly purchased from credible commercial vendors to deliver novel capabilities at a fraction of the cost today. However, the Pentagon does not deliver these capabilities at scale or at the speed of relevance to our warfighters on the ground today.

#### DIU MISSION AND RESULTS

DIU is the singular OSD entity embedded in U.S. innovation hubs regularly engaging with U.S. technologists, entrepreneurs, academics and investors. The PRC has already copied us with its own Defense Innovation Unit and also compels PRC companies to support the PLA through its military-civil fusion strategy. Rather than compel suppliers to work with the military, in the United States, DIU must streamline working with the Pentagon, so we can access more suppliers than the traditional defense contractors, whose business it is to accommodate whatever process and timespan DOD dictates. One-third of the DIU suppliers on contract are first-time vendors, representing 100 new companies that DOD can now access. While DIU has achieved no table successes, the Department and the Services must allocate orders of magnitude more of their budgets to non-traditional vendors in the startup technology ecosystem in order to solidify national security as a priority for entrepreneurs, technologists and investors.

DIU is a joint DOD organization focused on accelerating the adoption of commercial technology throughout the Services, Combatant Commands (CCMDs), defense

<sup>1</sup>Military and Security Developments Involving The People's Republic of China (2020), Office of Secretary of Defense, Department of Defense, pg. 25; Military and Security Developments Involving The People's Republic of China (2021), Office of Secretary of Defense, Department of Defense 24–29.

agencies, and other components and growing the national security innovation base. DIU partners with organizations across the DOD and the interagency to rapidly prototype, field, and scale commercial solutions that can save lives, lead to new operational concepts, increase efficiencies, and save taxpayer dollars. Through DIU's core operations and its components—the National Security Innovation Network (NSIN) and the National Security Innovation Capital Initiative (NSIC)—DIU cultivates talent, invests in emerging technology companies, and connects military challenges with existing commercial solutions. As just one example, DIU's work with SAR satellites, which can see through clouds and at night, are now providing commercial imagery of Russian forces on the Ukrainian border. This capability enabled the United States to predict the invasion, share with the world what was happening without revealing classified sources, and expose the Russian lies about de-escalation.

The investment DOD made in DIU 6½ years ago is bearing fruit. Since 2015, DIU transitioned 35 successfully-prototyped commercial solutions to Service partners. A successful transition means the prototype demonstrated success in a military environment, a production contract is in place, and a budget exists to scale capability to warfighters. DIU achieves this through follow-on, multi-year contracts—Production-Other Transaction (OT), Indefinite Delivery / Indefinite Quantity (IDIQ), FAR-based contract, and listings on the GSA schedule.

The 35 transitions represent \$3.5 billion in contract ceiling (~\$100 million average contract ceiling per transition) and led to additional DOD revenue opportunities for these new vendors via contracts not led by DIU. The largest example is the vendor Anduril with a \$1 billion follow-on contract from U.S. Special Operations Command (USSOCOM). This momentum in production contracts is accelerating, with contract ceiling totals growing substantially year-over-year. In fiscal year 2021 alone, DIU's eight transitions represented \$1.75 billion in contract ceiling—four times more than fiscal year 2020 and 50 percent of the cumulative total contract ceiling awarded since 2015. The \$218 million average in contract ceiling per transition in fiscal year 2021 is six times that of the prior year. In the first five months of fiscal year 2022, DIU facilitated the successful transition of an additional four capabilities.

The ability to convert a successful prototype into a production contract is generating greater demand from DOD mission partners to initiate more projects. For example, in fiscal year 2021, DIU started and cord 37 new projects, which is 50 percent of the total projects underway and double DIU's six-year average. Meaningful revenue outcomes and an increasing number of projects encourages more private companies to participate in solicitations—fiscal year 2021 saw a 40 percent increase in the average number of companies competing for a DIU contract. DIU has seen companies from 47 states, D.C. and more than a dozen countries compete for contracts. Growing DIU's capacity to lead projects will increase successful transitions and open up avenues to more contracts across DOD—all providing the positive economic incentive to sustain continued investment from venture capitalists and other private capital sources.

This past year, NSIN expanded DOD's reach as it integrated 4,566 individuals and 180 early-stage ventures into DOD through programs with its 71 university partners and directly supported the launch of 20 dual-use ventures from DOD labs.

NSIC, which addresses the shortfall of trusted private capital for dual-use hardware startups, received its first appropriation from Congress of \$15 million. With those funds, NSIC supported nine companies including products involving new battery chemistries and form factors, quantum sensors, and hypersonic engines.

#### DIU CHALLENGES AND RELEVANCE OF COMMERCIAL TECHNOLOGIES

DIU's successes represent well less than 1 percent of the overall DOD procurement budget. To modernize faster, DOD requires an order of magnitude increase in its adoption of commercial technologies. DOD is not leveraging the commercial sector broadly enough or fast enough in its modernization efforts. Commercial technologies have non-trivial differences from strictly defense-technologies. First, commercial technologies are supplied in massive unit volumes—sometimes in the millions—often led by the consumer as is the case with small drones. Second, in addition to larger volumes, commercial technologies evolve at a much faster speed than defense technologies with products refreshed on 12 to 18 month cycles instead of decades. As a result, DOD needs to move much faster in assessing and fielding these technologies. Third, commercial technologies such as AI software or commercial satellite imagery are not Service-specific. We do not need special versions for the Navy or the Air Force (even though at DOD we often try to create these) and, in fact, creating special versions by Service makes it more difficult and costly for commercial suppliers to do business with DOD. Fourth, since DOD does not control

the global diffusion of these technologies, our lack of adopting these quickly creates an asymmetric disadvantage if our adversaries adopt them more rapidly.

These differences are extremely relevant for conflicts we may face in the next decade where our adversaries effectively employ commercial technologies. For example, when United States troops were stationed in Iraq, ISIS sent small drones, which can be purchased on e-commerce platforms like Amazon, with grenades to kill American soldiers in Mosul. Countries such as Azerbaijan and Ukraine are quickly adapting commercial technology in new ways to gain an edge on the battlefield. Azerbaijan saw significant battlefield success in the 2020 fighting in and around Nagorno-Karabakh due, in part, to its use of commercial drones. *The DOD must add new capabilities like these in 1 to 2 years rather than 1 to 2 decades. However, this will not happen if we apply the same processes designed to cultivate defense-specific technologies such as hypersonics and directed energy—technologies with no existing commercial market—to dual-use technologies that are rapidly evolving in the commercial sector.* DOD must reform its sequential requirements, acquisition and budgeting methods to adapt to an environment where industry leads technology development and which prioritizes speed. The current sequential process lags commercial product cycles and delivers technology several generations behind which would be the equivalent of supplying flip-phones and fax machines to our warfighters today. While the Pentagon prides itself on following voluminous and well-specified DOD processes, the result is that in commercially advanced technologies such as advanced communications, artificial intelligence and machine learning, cyber and autonomous systems, we will be placing outdated, overpriced technology in the hands of our warfighters.

#### FAST FOLLOWER STRATEGY

*For commercial technologies that DOD does not invent, DOD must become a “Fast Follower” to gain rapid access to these technologies to maintain at least technological parity with adversaries.* This requires re-think of the 3 elements of how DOD operates:

- *Requirements*, where commercial technology negates the need for the time-consuming process of detailed specification of solutions;
- *Acquisition*, where some of the new adaptive acquisition frameworks (for urgent capability or middle tier) can be adapted for commercial technology and simplify the buying process;
- *Budgeting*, where new commercial solutions enter the market on a faster cycle than the 2½ year defense budget cycle and much faster than the refresh rate of traditional defense technologies, which can be 40 years or more for major platforms.

There has been so much reform of acquisition practices in the past few decades but almost no reform of either the *requirements* or the *budgeting* processes; we are encouraged by the establishment of the Commission on Planning, Programming, Budgeting, and Execution Reform in the Fiscal Year 2022 NDAA and hope the Commissioners will take on the requirements and budgeting processes, which are the greatest obstacles to increased use of commercial technology to modernize DOD. Key tenets of a Fast Follower Strategy include:

1. *Dedicate Organizations for Commercial Capabilities and Supply Them with a Consistent Budget.* DOD needs to establish dedicated organizations for each of the commercial technologies (e.g., drones and counter-drones, digital wearables and satellite imagery) which are not and do not need to be Service-specific. Today, it is not clear where in DOD these non-Service-specific technologies like small drones should be assessed and procured. With clarity of where the technology can be assessed and purchased, these dedicated organizations also need a stable budget for that capability. This is different from a program of record, which reflects a rigid requirement and often a single vendor. This is a “capability of record” where the need for the capability is on going such as for small drones. With that ongoing budget, DOD can assess capability on a more continuous basis, choose the best vendor at a point in time and refresh that capability with a frequency that matches commercial product cycles. Assigning an ongoing capability budget to these assigned organizations also signals demand to private industry and avoids duplication across DOD. In fact, this allows DOD to adapt to rapidly evolving threats and procure solutions that were not even available when the DOD budget was created more than 2 years earlier.
2. *Eliminate the Requirements Process for these Commercial Technologies* and replace this with a much more rapid validation of needs. Again, we do not need to develop detailed requirements for products the commercial market already

builds and, in fact, these requirements limit both creative problem solving from the commercial sector and the number of competitors.

3. *Apply the Best Practices of Commercial Procurement:* More widely apply non-consortia Other Transaction Authority (OTA) through Commercial Solutions Openings (CSOs), which maximizes competition while minimizing the opportunity costs of vendors to participate. DIU exclusively uses this method and experienced an average of 43 vendors participating in each of 27 competitions last year. Critically, if a vendor successfully prototypes a solution, there is no required re-compete at the end of the prototyping period, and DOD can immediately scale up the solution across the joint force. If Congress approves a budget supporting “capabilities of record” then we eliminate the DOD-unique valley of death which unfolds when we ask successful vendors to wait for the POM cycle to catch up—a process that can take up to 2 years and be death for a small company focused on cash flow.
4. *Coordination with Allies:* Source commercial technology from allies and sell proven solutions to allied militaries. Prevailing in the competition with the PRC requires more collaboration with allies and partners. The easiest form of collaboration is with commercial technologies which are unclassified and are, therefore, easily shareable and present excellent export opportunities for vendors.

This Fast Follower Strategy has several key benefits—*maximizing competition* through open assessments of solutions from multiple vendors; *reducing costs* by leveraging higher volumes of the commercial market; *increasing speed and transparency* of the acquisition process; and *minimizing the opportunity cost for vendors* which encourages participation in future competitions.

#### CONCLUSION

After a career as a high tech executive and CEO of two Silicon Valley-based companies, I have now had an in-depth immersion into how the military assesses and fields capability. DIU and similar innovation offices will not succeed unless DOD scales these efforts. As Eric Schmidt in his role as the Chair of the Defense Innovation Board said repeatedly, “The DOD does not have an innovation problem, it has an innovation adoption problem.” DOD has not yet established a complementary process to the one Secretary McNamara put in place in the 1960s for defense technologies. This means we do not have an effective process for the adoption of commercial technology, which represents 11 of the 14 critical technologies for national security. The Fast Follower Strategy is a common sense adaptation of how technology is adopted in the commercial world.

At DOD, we continue in a “business as usual” fashion at our peril. The PRC and Russia compel their private companies to work together closely with their militaries to gain experience with new technologies and concepts. From drone swarming to anti-satellite weapons programs, Russia and the PRC have studied our capabilities carefully and are rapidly modernizing its own military capabilities with a priority both on asymmetry designed to neutralize U.S. overmatch *and* accessing innovations in its commercial sector. The PLA is currently utilizing commercially-derived AI technologies to power drone swarms and underwater autonomous vehicles; the PLA is drawing from leading private companies for sophisticated ISR, information and electronic warfare solutions, and AR/VR for training, among others.<sup>2</sup>

The U.S. military will enjoy neither a time nor technology advantage if the PLA or Russian Armed Forces achieve more agility in adopting commercial technology. Imagine how well our forces will defend against PLA swarms of drones if we have not experimented with this concept. Imagine if we do not support more non-traditional suppliers of satellites or quantum sensors such that these technologies do not remain competitive in the U.S. and go the way of solar panels or small drones—controlled by the PRC.

The industrial base for defense continues to shrink—yet we have the power to change this. Supporting new dual-use technologies can create whole new industries based on biotechnology, resilient and greener energy, or construction of a space superhighway of satellites, space logistics and manufacturing as well as a multi-orbit transportation system. Otherwise, we cede to the PRC not only military advantage but the economic prosperity that comes with these new industries. The high technology economy of the U.S. is the envy of the world and based on technologies like the internet or GPS, which DARPA pioneered decades ago.

<sup>2</sup>Military and Security Developments Involving The People’s Republic of China (2021), Office of Secretary of Defense, Department of Defense, pg. 26–27, 148–149.

In my view, we cannot be complacent and must demand that DOD reform its Requirements and Budgeting processes—while more broadly adopting Other Transaction Authority to better assess, procure, and field commercial technology. I would ask for Congress' support by allowing for more flexibility in the appropriations process and providing consistent funding for commercial capabilities we know we need for decades to come. Maintaining our military's technological superiority requires us not only to continue to develop defense technologies like hypersonics or directed energy but equally important to fast follow the innovations of our vibrant commercial technology sector.

Senator KELLY. Thank you, Mr. Brown, and thank you all for your testimony. I will begin our first 5-minute round of questions, and then we will go in, I think, the order of folks as they arrived. This question will be for all three of you.

Promoting innovation is a critical task for DOD as we look to outpace countries like China. It is a full contact sport that requires attention and coordination across many offices and activities. It also requires considering not just the technical aspects of innovation like research and development but also a holistic focus on non-technical aspects, like workforce shaping, concept development, and wargaming, that are needed to accept and absorb these technological innovations into the military.

So starting with Secretary Shyu, what work has R&E been doing to invest in key emerging technology areas to address our warfighting needs, and how are those investments being used to shore up risks within the defense industrial base for emerging technology areas like hypersonics and microelectronics?

Ms. SHYU. So a couple of things I would like to talk about. Actually, several things I would like to talk about, and I will talk fast, is you have heard that we have initiated the RDER concept, the Rapid Defense Experimentation Reserve. This is a campaign of joint experimentation focused on solving the critical joint warfighting capability gaps. This is where we are going out to the services as well as to industry and the smaller companies to understand what prototypes do they have, that they have already developed that they can bring to us, and we can test in a contested, joint environment, to understand the utility of the prototype that they have developed.

What we want to do is leverage the opportunity to do these sprints, twice per year, to close the capability gaps, and have the Joint Staff as well as the COCOMs and the services to evaluate how well did these prototypes close the capability gaps and prove their utility. We want to be able to rapidly go into rapid fielding, or mid-tier acquisition, or leave behind the capabilities, or doing a design modification to enable different capabilities to be added to it, and come to the next sprint to demonstrate it out.

This could accelerate the capability from innovators all the way to fielding. This is exactly what we are doing, and fiscal year 2023 is our very first sprint.

Senator KELLY. Thank you. Dr. Tompkins?

Dr. TOMPKINS. I will add on a little bit to this, in the sense that what I will talk about I think dovetails into the RDER program that Secretary Shyu just mentioned. We are developing new ways of doing testing and evaluation, which is not just for testing and evaluating new technologies but also the concepts themselves. So when we have the ability to use modeling and simulation in order

to go through thousands of potential cases and different combinations of decisions and different combinations of circumstances, but at the same time building in new technological capabilities, it really allows us to figure out how to prioritize our investments, and then we take that, combine it with person-in-the-loop actual evaluation as these technologies are being developed, and live testing, in real time, feeding back and forth with the modeling and simulation. I think we dramatically accelerate our ability to look at specific needs, where the technology gaps might be, and what needs to be developed to fill those.

That overall capability is something that will be transitioned to the Test Resource Management Center under Ms. Shyu's organization, and we anticipate working with RDER funds, for example, in order to test out very specific subsets of these concepts.

Senator KELLY. Sometimes some testing is really, really hard to do, and you can do, through computational fluid dynamics and other methods, get at least the starting points you need of a test program. So it is good to see that you are doubling down on those efforts.

I am going to come back to Mr. Brown here on this question here in the second round, but for now let me defer to my colleague, Senator Fischer, for 5 minutes of questions.

Senator FISCHER. Thank you, Mr. Chairman, and welcome to all of you today. It is good to see you.

Secretary Shyu, you were serving as the Assistant Secretary of the Army for Acquisition, Logistics, and Technology during the Third Offset Strategy, and many believe that the Third Offset was unable to really satisfy Congress' questions about some very basic elements that the strategy had, and also that it delivered few tangible innovations from it.

Could you tell us, what are some of the relevant lessons you learned from that process, and are there challenges you think it revealed about attempting any kind of large-scale change within the Department?

Ms. SHYU. Senator Fischer, the Third Offset really highlighted, in a highly contested environment, what are the things we need to do differently. I can tell you, as an offshoot of that, was born ABII, Assault Breaker II. This is an activity that the Defense Science Board initiated, and DARPA has taken over whole-heartedly. What we need to do is come brief you in a classified setting to let you know of all the things we are doing under that particular activity. I think you would be incredibly impressed. We will be more than happy to follow up and come brief you.

Senator FISCHER. Okay. I know that RAND published a study on that last year, I think, and was saying that the Department was alerted to some of the erosion that we were seeing in U.S. technologies with regard to Russia and China. Is that what you are referring to?

Ms. SHYU. Let's see. I am trying to talk unclassified.

Senator FISCHER. Okay. Well, we will wait then. We will wait then.

Ms. SHYU. Yes. It basically highlights, in a highly contested environment, how can we conduct the fight. We will be more than happy to brief you at a highly classified level.

Senator FISCHER. Okay. Thank you.

Mr. Brown, your organization, the DIU, was one of the few tangible outcomes that saw in Congress from the Third Offset, and I realize that this does predate your time there with the organization. But do you have a view on this?

Mr. BROWN. To be more specific, a view on——

Senator FISCHER. The Third Offset Strategy and results that you have possibly seen.

Mr. BROWN. Well I would just say that as Chairman Kelly remarked, we are in a state where we are losing our technological edge, so I think what we are doing to reinvest everything from basic research, as well as we can do to stimulate that in the private sector, is exactly the strategy that we need to have to regain that. We may never gain the same level of offset or advantage that our adversaries do not have, but we have to make sure we are investing at the level where at least technological parity in many areas and exceeding what China can do in some.

So while Dr. Tompkins is inventing the future——

Senator FISCHER. No, that is good. Thank you.

Mr. BROWN.—we need to rely on the innovation in the commercial sector to bring that capability forward more quickly.

Senator FISCHER. Okay. That is good.

Secretary Shyu, Secretary Austin, he has talked about prioritizing hypersonics, and if watch any discussions on this committee, on the Senate Armed Services Committee, or in the Senate itself, you will know that this is an area of interest. I know that you have stressed the importance of making them affordable, and Secretary Kendall has also emphasized the tradeoff between the cost and the capability that is provided on them.

Is there a consensus view within the Department about what role hypersonic weapons will play and what technologies we should be pursuing?

Ms. SHYU. Absolutely. Thank you for bringing this up. This is certainly one of the critical technologies we are looking at.

I just want to highlight that the Army is going to be fielding hypersonic weapons to an entire brigade next year. The Army and the Navy together develop a common glide body. Navy will be fielding theirs on the *Zumwalt* DDG in fiscal year 2025. Air Force has developed a hypersonic weapon that is flying on B-52—they are still in testing—but they are initiating a program that will go on fighter aircraft. In addition, we are working with the Australians in developing a hypersonic cruise missile. So there are many activities ongoing, in addition to what DARPA is doing, pushing the envelope on the next generation.

I want to add one more thing. I think it is important to understand that we also have a university consortium of 80 universities working with small companies and large primes in developing the next-generation technology that we will be able to insert into our hypersonics programs. So we are progressing very rapidly.

The other thing that I think is very important to understand, we are really not in a horse race. You cannot think about this as a horse race. If you have 10, should I have 11? That is really not the right way of looking at this perspective, because we are developing

multiple different strategies. Once again I will be more than happy to come and brief you at a higher classification level.

Senator FISCHER. Thank you very much. Thank you, Mr. Chairman.

Senator KELLY. Senator Tuberville.

Senator TUBERVILLE. Thank you, Mr. Chairman. Thanks for being here today in this testimony. Talking about that Dr. Tompkins, I am from Auburn, Alabama. We have a pretty good university there, and we are proud of it.

You know, we do a lot of research on hypersonics and assured position navigation timing, cybersecurity. What stands apart for us is that our Auburn labs are 100 percent U.S. citizens, and that engineering student can conduct classified research for all national security. There does not have to be any hands tied. So we are proud of that.

Do you feel like we are investing enough in academic research at our universities to help with hypersonics and all these other basic researches that we are doing? Are we investing enough in that or are we depending too much on our technology industry?

Dr. TOMPKINS. The broader question of investment in the ecosystem is something I definitely should defer to Secretary Shyu on. But we work very, very strongly within this entire ecosystem, and we do not look just, for example, at companies or at government labs or at universities. We look at how they are trading off with each other.

I think there are certainly areas in which we could invest not necessarily more in quantity but think more creative about how we can connect students, faculty members and others into these more restricted research ecosystems without penalizing them in terms of their ability to, say, get their degrees quickly or their ability to actually publish on research. There is a lot of opportunity for creativity in that space.

From my perspective, it is less about sort of the volume of the dollars as to how effective we are able to deploy them, and I think there are some definite opportunities to be more creative.

Senator TUBERVILLE. Thank you.

Mr. Brown, I am glad to hear you talk about the commercial technology industry. I do not think we could survive. That is what we have over everybody else in the world. In Alabama, we have over 600 defense contractors. Most of them are on their own. A lot of them are small. I am very concerned about them being able to handle cybersecurity with the little money that they have, compared to the big boys, so to speak. They need to be protected as well as the others.

You can go from working on the hypersonic missile, you can go next door to somebody who working on a new tank, and next door to somebody working on the new lander for National Aeronautics and Space Administration (NASA). You can do it all. But a lot of them are small industries. How do we protect those small industries, because a lot of them cannot turn their computers on without China trying to steal everything that they have got. It is a tough road for some of them.

Mr. BROWN. Senator, I could not agree more. The industry I came from before being at Defense was cybersecurity, and it is an



escalating problem for us, the soft underbelly, are the small businesses that cannot afford to invest there. I think we need some help with some basic tools and hygiene, and I think Cybersecurity and Infrastructure Security Agency (CISA), at the Department of Homeland Security, has been moving forward at a great pace here.

What I think we have to do is make sure that we can provide some help with the basics for the small businesses, which is often hygiene, about making sure you have patched your software, et cetera. That kind of help, which is available both from the Federal Bureau of Investigations (FBI) as well as the Department of Homeland Security (DHS), is what we need to make sure we are doing enough to educate those companies and making sure they are implemented. That is how we help the small businesses, I believe.

Senator TUBERVILLE. Yes. You know, I do not know how many hundreds of thousands we are short on cybersecurity, and I will invite all three of you to come to Huntsville. They just started, 2 years ago, a program where they will take you in the 9th grade, full tuition, come live there, go to school, and by the time you are a 12th-grader, you are far and beyond what is going on in terms of cyber in our universities. I think that is the thing of the future, bypassing universities and start training these kids in high school. It is an amazing thing that is going on.

Just real quick, the Employee Stock Ownership Plans (ESOPS), the businesses that are owned by the employees, can you give a rundown, Mr. Brown, of what you know about those and how good they are? A lot of them, are they making it? Are they able to survive with employee-owned companies?

Mr. BROWN. So I do not have a strong point of view about this, because I have not—

Senator TUBERVILLE. Have you dealt with them before?

Mr. BROWN. I mean, many companies have implemented that, and I think the idea of having employees have skin in the game through incentive is a good one. It has been used in Silicon Valley, of course, maybe not with an ESOP program but with stock options, for years. So I think that is a good incentive system.

Senator TUBERVILLE. Yes. I think it is an edge for us in defense, especially.

Thank you very much. Thank you, Mr. Chairman.

Senator KELLY. Senator Scott will be recognized for 5 minutes.

Senator SCOTT. Thank you, Chairman. Thanks for being here. How many people work in each of your units? How many people work in your area, Secretary Shyu? Do you know?

Ms. SHYU. I do not have that exact number but I can certainly get back to you.

Ms. SHYU. The Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) is currently comprised of 1,202 personnel across the entire organization. The specific personnel categories are broken out in the table below. It is important to note that the Intergovernmental Personnel Appointment Act (IPA) appointees, detailees (DTL), and contractor personnel (CTR) numbers fluctuate regularly based on mission requirements.

Personnel Category	#
Civilian .....	186
Military .....	103
IPA .....	28
DTL .....	84
CTR/FFRDC .....	801
Total .....	1,202

Senator SCOTT. Do you know, Dr. Tompkins?

Dr. TOMPKINS. Within DARPA we have just under about 200 government employees, and we certainly have contractor support.

Senator SCOTT. Mr. Brown?

Mr. BROWN. We are 200 in total, which includes 20 Active Duty military, about 24 civilians, and the rest are contractors and reservists.

Senator SCOTT. Okay. How many projects do each of your units work on each year?

Dr. TOMPKINS. We start about 50 new programs a year, but we also end 50. We end about that many. So it means that we have about 250, approximately, active programs.

Mr. BROWN. We started 37 last year and we have 75 underway.

Senator SCOTT. Okay. Secretary Shyu?

Ms. SHYU. Yes. I cannot tell you because we cover across the entire DOD. I know just within AI alone there are more than 700 programs.

Ms. SHYU. The OUSD(R&E) has 49 different program element lines under its direct purview, and each of funding Program Element line is able to fund multiple programmatic efforts. Additionally, as the Chief Technology Officer of the Department of Defense, I have the core responsibility for advancing technology and innovation across the entire Department and the Department's science and technology programs. Considering artificial intelligence as an example, my organization makes substantive contributions to over 700 artificial intelligence related programs within the Department.

Senator SCOTT. Okay. All right. If you will get back to me and let me know how many people work there.

Mr. Brown, who, that you deal with in the Defense Innovation Unit, is the most friendly to your ideas?

Mr. BROWN. In the Department of Defense?

Senator SCOTT. Yes.

Mr. BROWN. We are finding that there is tremendous receptivity, demand for what we do among the services. Everyone wants to modernize, but I would say the constraints, which are dictated by our historical way of developing capability again start with requirements, a budgeting process that takes 2 or 3 years is the biggest inhibitor, which is why you heard my opening comments, not about technology but what we need to do to change so we can adapt and adopt commercial technology so much more quickly. We need Congress' help with that, and we need to change some things in the Department, so we can go faster. Speed is a very important competitive dimension in the race with China.

Senator SCOTT. In my business life we always had a sort of business plan. So what is you all's business plan for each of your units? Like you say, success is tied to what? What would be success be, starting with you? What is success? What do you feel like your purpose is?

Ms. SHYU. Success is going to turn a technology into a military capability and give us an advantage. That is the success we are looking for. But starting from basic research all the way to the end, it takes time to actually develop that, laser being a perfect example. It has taken decades, but now we are actually demonstrating we can shoot down UAVs—unmanned airborne vehicles—and we can shoot down cruise missiles. So we are showing extraordinary capabilities, and now we are in the process of fielding those capabilities.

Senator SCOTT. Dr. Tompkins?

Dr. TOMPKINS. Our mission is a really unusual one but it is very, very much focused on preventing and creating technological surprise. So what we try to do is we place many, many different bets on technology—high risk, high payoff. For us, success is going to be measured at different points in time. So at any moment in time we do look at our entire portfolio of current and recent programs, and we look for transition, through many different paths, into real-world use. But we are also always looking back, and what we are often finding is that something that we invested in one to 2 decades ago has been truly transformative and completely changed everything about how the military operates. Those are sort of the big bets that we are looking to make, and we are very proud of and we tend to think of as our big successes.

Mr. BROWN. So my job is a little easier than my colleagues in this. We have a crystal-clear focus, and it really builds on what Secretary Shyu said—getting capability in warfighters' hands. Because it is commercial technology, we often avoid all the classification issues that have come up here already, and we try and get that 1 year if it is software, 2 years if it is hardware.

So we measure, from a project start, when did we get that in warfighters' hands, which means successfully prototyped, it worked technically, production contract in place, and most importantly, budget lined up so it can start to scale. All three have to be met for a transition. We have done 43 transitions since we have been around, and that is a 45 percent transition rate.

Senator SCOTT. So Communist China has clearly decided to be an adversary. When you think about your jobs, do you say, "I am doing this because it is going to put our military in a better position, and this country in a better position to defend?" and how do you apply that?

Ms. SHYU. One of the things that we do do is we do a net assessment. Namely, we take a look at what is our capability. We also take a look at what is the red capability. That informs us where we need to go. It informs us what we need to invest in to get ahead of the threat. So that is done in step one. So investment in a lot of our technology priority areas is informed by where we need to head, and I think, if I could come in and chat with you at a classified level I can talk about how these pieces are literally stitched together to give us an asymmetric advantage.

Senator SCOTT. Thank you, Chair.

Senator KELLY. Thank you, Senator Scott.

We will now go into our second round of questions. I want to get back to Mr. Brown for a second. In the beginning of my first question we were talking a little bit about non-technical aspects, like workforce shaping, concept development, and wargaming. I asked Secretary Shyu and Dr. Tompkins to comment on investing in key emerging technology areas to address their warfighting needs. I think for DIU it is a little bit different with the commercial technology.

But let me ask you this. How often do you see companies out there and you identify things—like what percentage would you say are actually emerging technologies, and then do you ever get to the point where you realize that some company is so far out in front of maybe our adversaries that have to consider, do we need to classify their intellectual property? Is that ever a consideration as DIU identifies commercial activity?

Mr. BROWN. Senator Kelly, the model for DIU is not to set our own priorities. So, you know, the time frame that Dr. Tompkins has is considerably longer. We are about what can we field quickly.

So our priorities come from mission partners, the services, another part of DOD that says, “We have got an urgent problem,” and then we match that with what is available today. So that ends up being different technologies to work on. It is a portfolio—one in AI, one in energy, cyber.

Senator KELLY. But as you are doing that you must come across things unexpectedly.

Mr. BROWN. Yes. Most of the times I would say we do not see things that need to be classified, and, in fact, in my own personal opinion we overclassify things so it makes it more difficult to work on. I have not encountered one of those in my tenure that I feel like we have got to rush to make this classified.

I think the more innovative it is, it pushes me the opposite way, to feel that we need to go faster, because our adversaries have access to commercial technology as well. So we need to make sure we are including that in warfighting concepts and funding that so that we can bring that to our warfighters.

I think the constraints we talked about earlier that inhibit our ability to get the commercial technology more quickly adopted just put our warfighters behind us, behind in terms of commercial technology and then certainly versus adversaries.

Senator KELLY. Thank you. I want to follow up on Senator Fischer’s question about hypersonics with Secretary Shyu. She was talking a little about cost versus capability, she referenced Secretary Kendall’s comments about hypersonics, and I am a strong believer that we need to catch up in our hypersonic missile technology. Secretary Shyu, you talked about putting all the parts, I think, together. But really what we are looking at is increasing our Pk, probability of kill, on a target.

So as you look at hypersonics do you feel that this is the future to increase the probability of destroying a target, or do you sometimes consider existing technology, improving that, that would give us a higher Pk?

Ms. SHYU. That is a great discussion in which we actually have done analysis in. I think we should come back and brief you—once again, it is unfortunate—at the classified level. But we can show you the analysis that has been done at a campaign level that looks at conventional weapons as well as hypersonic weapons, to attack against different types of targets. So we have done that analysis. We will be more than happy to come and brief you on that. If you can give us an hour of your time, we will go down to a Sensitive Compartmental Information Facility (SCF) and have a great dialogue.

Senator KELLY. I will take it, and Senator Ernst, if you are ready.

Senator ERNST. Yes. Thank you so much, and for everyone, please, if you identify a technology that is viable for the warfighter, and if all of the departments' existing authorities are employed, how quickly could that innovation be fielded for our warfighters? I would just love to hear from all of you. Secretary Shyu?

Ms. SHYU. Senator Ernst, I think it depends on the particular type of technology, because there are some technologies, potentially, if it is commercial we can leverage it very quickly. If it is something we need to develop, due to the type of threat that is demanding us to do that, it may take a little longer to develop. But it really depends on the type of technology.

Dr. TOMPKINS. I have to agree. I can think of examples where we have seen things, for example, with traumatic brain injuries with warfighters, where we were able to very quickly adapt commercial technology. It was not quite what we needed, and so within a year of adaptation we were able to then work with the military to get those deployed out for soldiers.

On the other hand, when it is some type of a munition, when everybody is all in—so as I think we demonstrated in partnership with the Navy when we were working on the Long-Range Anti-Ship Missile (LRASM)—you can do in single-digit numbers of years, but the entire Department has to be working together in order to remove any kinds of normal process-based obstacles.

Senator ERNST. Okay. Thank you.

Mr. BROWN. If the technology is commercial and we do not have to go through the development part of that, so our goal, beyond the goal of getting as many things across the line to the warfighter as possible is how fast did we do it. With software, the fastest we have done it, from a concept to actually implemented by warfighters, it was a piece of software for United States Northern Command/North American Aerospace Defense Command (NORTHCOM/NORAD), in under a year. But the gating time on that is the testing time that we want to take, because there are big consequences of making mistakes. So we do not want to compromise on that. So 1 year for software, 2 years for hardware is the target we are currently trying to beat with commercial technology.

To make sure the business process is friendly for commercial companies we try and get them on contract in 90 days. So that is lightning speed for DOD, but it is commercial terms.

Senator ERNST. Right. No, and thank you. I have spoken with a number of leaders in Silicon Valley who have made it clear that they could field technologies and weapons systems ready for experi-

mentation with DIU in the Nevada Test Bed in the next 90 days. So I do believe the Department of Defense must move toward the pace of private industry, when at all possible, and that any steps we can in that direction are very, very important. However we can move that direction I think we should. I know there is going to be some differences with the different types of systems. But we have to be able to field systems as rapidly as possible, and I am so concerned that sometimes we get so wrapped up in red tape and the budgetary cycles, we need to think about innovation and how we field quickly.

So that is my little rant for this period.

Just in some time that I have remaining, Secretary Shyu, in your assessment, what is Silicon Valley and the defense small business enterprises' capacity to field prototypes for weapons and logistics support equipment if tasked today with, for example, developing missile or an Intelligence, Surveillance, and Reconnaissance (ISR) prototype, something like that?

Ms. SHYU. I think there is tremendous capability into commercial. I will give you an example in the commercial world. Elroy Aircraft. They are strictly a commercial company but they have developed a cargo UAV that can fly 300 miles and carry 300 pounds of payload. So for logistics, this would be fantastic. If the Government literally can just buy something commercial off the shelf, we do not have to pay for the development. It is paid commercially.

So absolutely, this is exactly where we are teaming up with DIU, to look for these types of capabilities that literally we can just buy rather than trying to reinvent.

Senator ERNST. Right, and I think, Dr. Tompkins, that was maybe what you were referring to as well, to be able to procure something and make minor modifications, where necessary, right? Yes.

Dr. TOMPKINS. Yes.

Senator ERNST. Thank you. I yield back. Thank you.

Senator KELLY. Thank you, Senator Ernst. Senator Kaine.

Senator KAINE. Thank you, Chair and Ranking. Important subcommittee. I want to say hi to Mike Brown, who is an old friend, and I would say if you guys ever want to do a really good field trip, when you are in Silicon Valley go by DIU, because you will really see great things. I had a wonderful visit a few years ago and remember it well.

Secretary Shyu, I want to ask you this question. Now you have been in your position for almost a year. Do you think that the split of AT&L [the position of the Undersecretary of Defense for Acquisition, Technology, and Logistics] into two divisions had a positive impact on fostering innovation?

Ms. SHYU. There are pros and cons.

Senator KAINE. I am more on the con side myself, I am going to say, but I am not doing it every day. So those who do it every day certainly have better-informed view than I do.

Ms. SHYU. I would say on the positive side—I will give you both perspectives. On the positive side, I can spend more of my time on the research and development on the S&T side. On the con side, namely you have got two people that are going to be sitting in multiple meetings now, and you have to literally link arm-in-arm.

There are all those meetings within the Pentagon, I have to be linking the arm with A&S. Otherwise, I am going to create an island of just S&T that never transitions, which is not what I want to do.

Senator Kaine. Can you give me an example? So how do we mitigate the downside of that con? So you do it by linking arms. Can you give me an example of a project or something you are working where you think it is working well, where you have got arms linked and something is being delivered or done that you feel good about?

Ms. SHYU. I am looking forward to Dr. Bill LaPlante's final confirmation so we can actually link arms to work on a number of these projects together. I can guarantee you, I cannot wait until he is on board. There is a whole slew of stuff we want to do together.

Senator Kaine. I guess that would another con of splitting them into two is if you get one confirmed and the other is not, then you have the one function that is ready to go and then you are kind of waiting around to link arms with your colleague on the other function.

Sometimes in this Committee we do this, but we probably do it even more when we are thinking about budgets and appropriations. We talk about the defense budget and the non-defense budget, and yet there is so much in the "non-defense" budget, whether it is the nuclear programs in the Department of Energy (DOE) or whether it is National Security Division (NSD) programs, where I feel like the distinction between defense and non-defense budget is somewhat artificial. Particularly when you get into research and science and so many different agencies where to do your work really, really well you have to have arms linked not only with your colleagues in the Pentagon but with the agencies outside the Pentagon.

Talk a little bit, a year in, how good you feel about the stakeholders being at the table together rather than siloed, as we are tackling these emerging threats and issues.

Ms. SHYU. I would say one of the things that we are working very closely in the microelectronics area is with the Department of Commerce, because we have to. I will tell you on a lot of the other things, and hypersonics is an example, we are working very closely with the Department of Energy, because the common glide body was developed by Sandia, and the technology is being transitioned to the services. So we do have close collaboration across the different agencies.

Senator Kaine. That is good, because in this defense versus non-defense budget, like Department of Energy, a citizen might think that is all like, you know, promoting American energy companies. No. Overwhelmingly that is taking care of the basic nuclear labs and other research and other assets that lead to the construction of the reactors in Lynchburg that get put on a train down to Newport News and then put into subs and carriers. So all these non-defense agencies, many of them have very direct ties.

Coast Guard is a non-defense agency in the sense that it comes up through DHS rather than DOD. Many of the law enforcement agencies that are working on drug interdiction in the Americas, they come up through the Department of Justice (DOJ), not through DOD. But we have to really, really, as you say, link arms if we are going to do a good job.

Those are all the questions that I have for now, but I really appreciate the chance to come and encourage fewer silos and more arm-linking.

Senator KELLY. Thank you, Senator Kaine. That is the end of Round 2. We will go to a third round of questions. I want to maybe start with Dr. Tompkins here, and to follow up on something that Senator Ernst mentioned in her opening remarks, and that is the valley of death for some of these technologies. A recent Government Accountability Office (GAO) report highlighted this.

You know, DOD has struggled to transition some early-stage R&D into real acquisition programs, and if we are going to be competitive with China and Russia on some of these technologies we have got to do a better job of getting across that valley. It is very frustrating for folks out there that want to work on emerging technologies and get them to DOD, things like artificial intelligence and space systems and all kinds of stuff.

Actually, the question is for anybody. Is this a problem that any of your organizations can actually quantify in any way? Do you have any statistics on it, or some data or anecdotes? Do you know how many of the technologies developed in your organizations, or in the case of Mr. Brown, commercial off-the-shelf just actually do not get to the warfighter?

Dr. TOMPKINS. Statistics, as you can imagine, are really hard to keep track of, because at any moment in time they might change on you. I think the last numbers I saw, where we tracked transition across, say, eight different avenues, we were tracking about, I think, 23 percent that simply did not go anywhere, in the sense that usually for us that means we failed because we were trying something really crazy and it did not work.

Senator KELLY. Sometimes that could be the case, it is just never going to get there.

Dr. TOMPKINS. Right. But for everything else things are moving.

Now, of that, I do not know exactly what percentage directly reached the warfighter, because some of them might be in a program of record and it is not quite there yet, or it might be in another government lab, working through the final maturation stages.

But it is a topic we are very, very concerned about, and one of the reasons that we have spent so much more time focusing on commercial transition support to companies that start up, based on having developed DARPA-funded technologies.

Mr. BROWN. I would like to start by building on what Dr. Tompkins said. She has a program, the Embedded Entrepreneurship Initiative, for successful companies that are coming out of DARPA programs. So she is trying to provide some support there, and we are trying to also pull there to make that a premier set of companies that we would look to at DIU.

We have, really, two different arms at DIU. One is an investment arm that Congress authorized in the McCain National Defense Authorization Act (NDAA), National Security and Innovation Capital, to promote private investment in hardware, because private industry does a great job supporting software, a little bit less for deep tech, and that is a lot of what Dr. Tompkins does. So with that we have some money that we can provide for those vendors.



That helps them get across one or two of the valleys of death, maybe getting a company formed, maybe scaling up manufacturing. We are going to look to the successful DARPA companies as one of the sources there.

Then, of course, there is DIU itself, where we provide revenue for companies who are prototyping or testing with us, and we want to have them see production revenue. So we are looking at what is the ongoing, recurring revenue that stimulates more investment dollars to come in to fund these companies that are supporting national security.

From a percentage standpoint, I would say that 25 to 30 percent of the projects we work on have some problem getting the money in place—the right color of money—getting money in the right time frame. This is the link to the budgeting process. Because some of the new technologies come up, or emerging threats come up within a budget cycle, and then, as we know, it is very difficult to move money around. So that is a real problem and it frustrates, I would say, 25 to 30 percent of the efforts we work on, where we get a company that has successfully prototyped but cannot get to the warfighters' hand until the budget matches. Frustrating.

Ms. SHYU. I would like to add onto that, if I may. We have talked about the multitude of different ways to do transition, from technology. One path is transitioning directly into a program of record. Another path is if you are transitioning to commercial. Another path would be you have transition to a prime contractor who is going to design and develop something that ultimately the DOD will buy, and then there is also a transition path of software that went directly into the hands of the operator.

There is also another different way of transitioning. You can transition to Tier 2, Tier 3, Tier 4 contractor, who may design and develop components that go into a prime that transitions into the DOD. We have no contractual mechanism to track that, ergo, the difficulty in trying to figure out exactly which technology you have funded that transition directly.

The other piece, and I want to give you an example, of technology takes time to transition. One of the DARPA programs that funded is a microwave packaging. It was like a \$1.5 million microwave packaging contract. It spawned an idea, to figure out how do I design and develop a very innovative architecture for active electronically scanned array, which is critical for the next-generation radar system. It developed something, you know, a prototype, from internal research and development. From that particular effort, when I came on board, I looked at that technology, and I said, "That is really innovative." It was funded from DARPA, transitioning into array technology. I took that technology, matured it, developed it into a prototype, which then ultimately helped Raytheon, at the time, to win the F-18E/F contract, which it fielded in production.

So you can see the long time frame. It took a decade to get there. But ultimately the sealing contract that was provided from DARPA spawned off an entire product line which resulted in billions of dollars in terms of profit.

So that is a transition. Nobody probably has a record. I knew it because I was involved in it.

Senator KELLY. Senator Ernst.

Senator ERNST. Oh, I appreciate it. Secretary, we talked yesterday a little bit about the RDER program, as well, which I am fascinated by. Does the program address the speed of fielding technologies for the warfighter? Do they talk about time frames and when they want it fielded? Because with the 32 technologies you selected for demonstration, can we expect any of those technologies to be delivered in 2 years or 5 years? Maybe if you could walk me through that, and how you determine how long until fielding.

Ms. SHYU. So the whole intent of RDER is trying to expedite the capability into the hands of the warfighter as quickly as possible, by closing the joint warfighting capability gaps. So we are looking at technology. We can literally demonstrate, in 2023, 2024, and be able to push it out by 2025. So we are trying to compress the timeline, and not wait a decade to push the technology out.

So one of the aspects of being able to accelerate capabilities into the hands of the warfighter is once we determine, the Joint Staff and the COCOMs determine there is operational utility of having this particular prototype, I need to have a mechanism, a funding mechanism to rapidly transition this technology.

One of the things that we are going to ask for is, is there a pot of money that we can ask to transition to mature this so I can help the company who produced this, especially if it is a small company, to ramp up production. Because if they deliver a few prototypes to you, and all of a sudden you saw the powerful utility of this and you want to buy 1,000, they cannot flip a light switch and give you 1,000 tomorrow. But I would love to be able to help them bridge the valley of death and not wait 2 to 3 years for the Program Objective Memorandum (POM) process, the Planning, Programming, Budgeting, and Execution (PPBE) process, to catch up to buy this. This is exactly why small companies die on the vine.

Senator ERNST. Right. Thank you. I appreciate that very much. then, as well, we talked a little bit about special forces as well. We have some authorities that they utilize. Does the Special Operations Forces Support Agency have the capacity to deliver innovation to the warfighter quicker than what we see with general DOD timelines?

Ms. SHYU. Yes because they take mature technology. They are not trying to take immature technology and develop very basic science. They look at what is the stuff that is out there today, that I can literally rapidly buy and field? So their timeline is very compressed. They are not trying to develop next-generation fighter aircraft. They are looking at, hey, what can I get very quickly? It is more like a DIU model.

Senator ERNST. One thing that we might want to do, too, is just look at the existing authorities within their programs and see if some of those could be applied, DOD-wide.

Mr. Brown, did you have some thoughts, as well?

Mr. BROWN. For me it is less about authorities. As I talked about in my opening statement, a lot of the authority already exists within DOD. We need to change some of our processes. But the authority that does not exist Secretary Shyu just talked about, the flexibility of moving money, to get it where it is needed most. I realize why those things existed historically, but now we are in a serious tech competition with China, and they are not waiting for our

democratic time frames. I like our system better than theirs, but we have to figure out how to move more quickly.

Really, from a technology adoption point of view, whether it is commercial technology of inventing the next technology, it is about having the flexibility to move it where it is needed most, in a simpler fashion than we have today. I think that is the most critical element we need to attack between Congress and the Department to improve our defense.

Senator ERNST. Yes, thank you, and I think this is a big takeaway for me, and I think for a lot of folks as well, is that maybe not so much about the authorities but maybe more about flexibility, within parameters, of course, because we do have to be good stewards of those dollars. But, of course, greater flexibility so we can keep pace, I think is really great.

Thank you very much. I appreciate the information.

Senator KELLY. I would like to talk a little bit about microelectronics with the three of you here for the next 5 minutes. So secure access to microelectronics is a key enabler for so many of our technologies, not just for DOD but our defense industrial base. Our market share has shrunk in the production of these, from upwards of 40 percent to 12 percent today, and if we do not do something about it, it is going to get below 10, and that is not good. Also the most sophisticated foundries for semiconductor chips are now overseas, and this creates just a dangerous reliance on foreign sources.

That is why I have been part of leading this plan on a \$52 billion investment that will support bringing this manufacturing capability back to the United States, and it also will establish a dedicated microelectronics network within the Department that leverages the expertise in our universities and in industry. I would like to thank Secretary Shyu for working with me on this effort, and I know it will help us overcome current challenges in supply chain security and disruptions and the problems that this creates for the Department of Defense.

So I would like our witnesses to address how the paradigm for trusted microelectronics needs to change so we can better leverage commercial practices and economies of scale. Starting with Secretary Shyu, can you begin with what the Department is doing to break the outdated, dedicated, trusted foundry model that has been used since the early 2000s? You know, we do not do most of the technology work the same way that we did 20 years ago.

Ms. SHYU. First of all, I want to thank Congress for giving us the \$52 billion. I think it is absolutely critical for this nation to onshore some of these critical capabilities. As we have seen during the pandemic, we cannot get our hands on the microelectronics. This is a tremendous impact on our industries across the board. So thank you very much.

I would say there are several things that we are doing. The Microelectronics Commons is going to be a critical enabler. The funding that you have given us is going to fund \$400 million per year for 5 years to build a lab-to-fab facility that is regional. That is going to help the university to create the next generation of materials and processing technology, to test it out in a regional fabrication facility, and have the ability to transition this technology

to a production facility. It is going to help our entire infrastructure. So that is absolutely critical.

The other piece that we are funding within the Department of Defense is the Rapid Assured Microelectronics Prototype commercial, namely we are focused on providing a leading-edge capability, less than 3 nanometer wafer foundry. That is absolutely the state of the art.

We are building that capability in the U.S., and it is also going to strengthen our domestic industry and establish a sustainable ecosystem, because we are teaming up with fabulous companies as well, who can then design within this commercial foundry. What we are looking at is leveraging the state-of-the-art commercial processes and putting on top of a layer, potentially for classified chips that we may need. But literally, we are absolutely leveraging the commercial state-of-the-art foundry.

Senator KELLY. I cannot stress how important it is that we finally get this across the finish line. You mentioned we have given you the \$52 billion, but we still have some key steps to go here. We are close. This is incredibly important to our national security. I do not think this can wait months. The United States Senate and the House should figure this out this week, and if not this week, as soon as possible. We run the risk of other countries in Europe making these investments. There have been proposals that they have made that substantially, I would say, are above the proposals we have made here. So time is of the essence on this, and we have to get this across the finish line.

I do have a couple more questions if everybody has a few more minutes. I want to talk quickly about some biotechnology and genetic data. You know, our ability to leverage biotechnology and decode genetic data has grown by orders of magnitude over the past three decades. That is why mine and my twin brother's DNA is available to everybody online, thanks to my former employer. I did allow it—they did ask—but it is there.

Much of that ability right now lies in the private sector, and that means competitors like Russia and China can buy these and try to exploit sensitive information.

So maybe we start with Dr. Tompkins here. How concerned are you that nefarious actors or near-peer competitors are using genetic data for bioweapons or intelligence gathering?

Dr. TOMPKINS. That kind of question is one of many that tends to keep us up at night, as you can imagine. Obviously, I think the kinds of questions you are asking are also very much more part of the intel community. We use the information from them, however, to think about safety, security, and defense, and so what we tend to do is think about how one might very quickly chase down and erase some type of customized capability like that, as well for accelerating our own innovative capabilities, building security from scratch.

Our program Safe Genes is a good example of that, and we are obviously thinking about other defensive kinds of capabilities that are less easily discussed in this type of an environment.

Senator KELLY. Does our growing capability or ability to decode data offer us any mitigation strategies here against bioweapons or

other intelligence exploitation? This is for anybody, if anybody has a comment on this.

Dr. TOMPKINS. One thing I can talk about, it is still a way away from being ready for prime time, is specifically looking at the epigenome, so not just at the genetics but at sort of some of the proteins and things that are hanging off of the genetic information. We have several programs exploring how you can use information in the epigenome to tell you whether somebody has been exposed to weapons of mass terror, weapons of mass destruction, precursors, things like that, and also exploring ways in which those things might be triggered to provide advanced protection.

Senator KELLY. Any other ways we can guard against potential threats in this area?

Mr. BROWN. I will just add a different dimension to this from the sciences. This is one of the areas of emerging technology where the government can play a role by really assisting commercial companies with developing that technology. What I mean by that is being more forward-leaning in terms of contracts to develop the capability. A capability that exists in our commercial sector right now to sequence all pathogens, and that could be happening globally, but there is no program to make that happen.

We should be experimenting with these capabilities, funding some of these companies, so that the U.S. is on the forefront of this technology. I think that is going to be critical. Just like it was in the space race in the 1960s versus the Soviets, the government was very forward-leaning and developed lots of new technology. This is another area where I think we need to be forward-learning with the industrial base.

Senator KELLY. Thank you. The GAO and others have recently highlighted the challenges that DOD faces in attracting and retaining a highly skilled technical workforce, and I imagine for all three of you, I mean, that is the whole ball game, you know, having the workforce to do this work. It does not matter if it is artificial intelligence or hypersonics or anything, for that matter.

I have spent some time getting up to speed on what China is doing here and how we stack up. You know, there is more we need to do. So, Secretary Shyu, can you share, what is DOD doing to acquire and retain the talented people that we need to develop and deploy things like artificial intelligence and other emerging technologies?

Ms. SHYU. You bet. One of the things that the DOD has done is create the Smart Scholarship-for-Service Program. Last year we funded 416 scholars for their undergraduate and graduate degrees, if your field is in one of the 21 STEM areas that we are interested in. So these students, their scholarship is being paid for, and when they graduate they come and work in one of the 101 DOD laboratories.

We had great success stories so far, and I can tell you, out of the 416 SMART scholars, 50 percent of them were women, for which I am thrilled, 20 percent were from underrepresented minorities. I would say nearly half of these 416 SMART scholars are pursuing degrees in computer science, in software, in artificial intelligence, which is fabulous. We are leveraging those SMART scholarships to support them in growing our bench strength.

If you look at over the years, in the last 2 years, we have had 561 scholars that transitioned to their employment after they finished their degrees, and 70 percent of the SMART scholars, after they finish their service obligation, decided to stay with the DOD laboratories. That is a huge success story.

The other thing that we are doing, and beyond doing just the scholarship piece, we actually awarded 28 grants, at \$82 million, to develop K-20 education. Again, Arizona State University, their curriculum for biotech is targeting minority and rural areas in Arizona. You want to increase your bench strength in the future.

The Department, through the National Defense Education Program, created 10 STEM summer camps. Literally, we took the opportunity to pull in 1,200 junior high school students and gave them a week-long STEM camp. They loved it. It was a highly successful education program that we have done, getting junior high school students interested in science and technology, and we want to grow that next year.

So we are doing a number of things that we can reach down, not just at the university level but lower levels as well, to encourage them to go into STEM.

Senator KELLY. Thank you. Dr. Tompkins or Mr. Brown, any comments? I think is a good question to end on too, because it is so central to everything all of your organizations do.

Dr. TOMPKINS. I will offer an example of a type of initiative that DARPA specializes in, because it allows us to continue to sort of fund projects as part of what we do, and that would be the Joint University Microelectronics Program, called JUMP. That is nearing the end of a 5-year program lifecycle, and we have just announced the start of the call for proposals for JUMP 2.0.

But this is a university-government-industry consortium, and it is a model that universities themselves often use on a much smaller scale, where you might have a handful of companies together paying into the support of students and essentially developing the pipeline and research baseline for the workforce development.

In our case, we are talking about 35 universities, over 1,300 students in the last 3 to 4 years, hundreds of researchers across I think about a dozen or two states, where that pipeline directly connects U.S. university students to U.S. both defense and commercial and sometimes allied nation companies in order to significantly build up that workforce.

We are not necessarily targeting government labs specifically but what we are very much doing is trying to target that overall U.S. program.

Senator KELLY. Thank you.

Mr. BROWN. I am going to be the skunk at the party on this one. I think what the Department does on fellowships, internships, is fantastic, and we need more STEM talent for the competition with China. We should contrast that with how difficult we make it to bring incredibly qualified people into the Department.

One quick example. At DIU we are very lucky to attract a Rhodes Scholar, PhD in computer science from Stanford, who wanted to work for us at a government salary. Seven months, once we identified that candidate to get him in the door. I do not know what we do with that time, and this predates Secretary Shyu. It

is the administrative process that we have at DOD that are—I cannot even explain why it would take that long, for what, in the private sector, would have taken seven days, we would take seven months to do.

We cannot attract the best people if we do not recruit them and have a better process experience.

Senator KELLY. Could you find out, and go back and find out who we could talk to? Because if we can identify why it takes seven months, Senator Ernst and I, we could probably, with some help, figure out what we need to do to speed that up.

Mr. BROWN. We would love to tackle that. I hope Secretary Shyu will share my enthusiasm for that.

Dr. TOMPKINS. If I may add, as I have mentioned several times how grateful we are at DARPA for the authorities and flexibilities that you have granted to our organizations, we can typically hire within a week, Mike. So the problems are solvable.

Senator KELLY. Okay. We need to go to that model.

Ms. SHYU. Sir, one more final thing. I think it important, because you bring them in at the salary level at which government pays. You are nowhere competitive against the commercial industry, who is going to pay them twice as much or three times as much. So that is a disadvantage that we have.

I can tell you one example. I spoke to an individual with a PhD from Stanford. He had two very high-paying offers. I literally spoke to him, “Look, for the sake of national defense you need to take a job and work with me, at a much lower-level salary that I can pay you. But just think of the perspective in the visibility that you will get working with me.”

So, literally, I talk him out of an extremely high-paying job to come work for me, and he is coming on board.

Senator KELLY. Great.

Ms. SHYU. So yes, it is the authority, the flexibility in pay that we do not have, which makes it very onerous in terms of trying to attract talent.

Senator KELLY. Well I want to thank all of our witnesses for participating in today’s hearing but also for leading your agencies and serving our country. I believe, you know, very strongly in the work you are doing, and it is important that we continue to not get our eye off the ball here, to focus. I am convinced, long term, we will out-invent and out-innovate our competitors as long as we remain focused on it and you have the tools you need. So please, let us know what you need.

I just look forward to continuing to work with you, and this hearing is adjourned. Thank you.

[Whereupon, at 4:02 p.m., the Subcommittee adjourned.]

[Questions for the record with answers supplied follow:]

#### QUESTIONS SUBMITTED BY SENATOR MARSHA BLACKBURN

##### HYPERSONIC DEVELOPMENT

1. Senator BLACKBURN. Mr. Brown, what specific challenges do aging infrastructure pose to testing modernization?

Mr. BROWN. Aging infrastructure increases test costs, delays test schedules, and limits the value of data collected during test events. The Department of Defense (DOD) Test Resource Management Center (TRMC) is addressing test infrastructure

modernization needs through strategic planning and targeted investments to deliver both the capabilities needed to test developing weapon systems and the throughput required to test at the scale and speed necessary to keep pace with rapidly advancing technology.

2. Senator BLACKBURN. Mr. Brown, how does software advancements impact infrastructure in the short- and long-term?

Mr. BROWN. Software advancement enables the Department to more efficiently evaluate data collected during test events. As an example, the TRMC is developing software solutions that incorporate big data analytics to significantly accelerate post-test data analysis.

#### DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)

3. Senator BLACKBURN. Dr. Tompkins, what has DARPA learned from the unmanned UH-60 Black Hawk maiden flight? What challenges arose from the unmanned UH-60 Black Hawk maiden flight, and how is DARPA addressing them?

Dr. TOMPKINS. The successful maiden flight of an uninhabited UH-60 Black Hawk proved the technology is mature for broader use and that this capability is ready for delivery to the Army for follow on development. As an Optionally Piloted Vehicle (OPV), a UH-60 Black Hawk leverages existing assets to provide wide benefits for force multiplication, sustainment, logistics, and operational effectiveness. While no significant technical challenges were noted, there is currently no follow-on funding for UH-60 Black Hawk autonomy.

#### PATHFINDER MODEL

4. Senator BLACKBURN. Ms. Shyu, what challenges have you identified in reviewing the Pathfinder model, and are we maximizing partnerships with academia?

Ms. SHYU. The Pathfinder program is a model that the Army is currently evaluating that seeks to create greater connectivity between the warfighter and academia in order to focus on warfighter challenges. I view such models as effective ways to engage users with the innovation ecosystem at much earlier stages and look forward to understanding and leveraging any lessons learned from the Pathfinder program throughout the Department via the Innovation Steering Group that I lead for the Deputy Secretary of Defense.

In addition to programs like Pathfinder, the Department is maximizing its partnerships with academia through its basic research programs, its Historically Black Colleges and Universities and Minority Institution programs, the Small Business Technology Transfer Program, and through numerous educational partnership agreements and cooperative research and development agreements (CRADAs) between the DOD and academic institutions. The Department values academia both as a hotbed for invention and innovation and as the source of a talented science, technology, engineering, and mathematics workforce for the Department and the nation.

#### RECRUITING AND RETENTION

5. Senator BLACKBURN. Dr. Tompkins, what action is necessary to better develop, recruit, and retain talent within emerging technological expertise?

Dr. TOMPKINS. DARPA's mission to engage in high risk research to prevent strategic surprise rests on a talented workforce with unique expertise. DARPA is grateful to Congress for the direct hiring authority that allows us to attract experts in science and engineering and hire them in a timely manner. Last year, Congress made two additional changes that have strengthened the authority. The streamlined pay modification eliminated a burdensome and unnecessary two-step process that will decrease administrative load and also reduce paperwork errors. The relocation expense changes to the Joint Travel Regulations will allow us to provide greater incentives to attract program managers who would need to temporarily relocate their families while serving at DARPA. These two changes are working well and there are no current challenges.

6. Senator BLACKBURN. Dr. Tompkins, how is DARPA utilizing innovative workforce development, recruitment, and retention techniques to collaborate with academia and industries?

Dr. TOMPKINS. DARPA takes a multifaceted approach to workforce development and recruitment by participating in outreach events across the country to reach new performers and program manager candidates.

For example, DARPA has begun planning DARPA Forward, a large outreach effort aimed at discovering and engaging new communities of talent and energizing the DARPA innovation ecosystem. DARPA Forward will include six regionally-based



events across the country culminating in a showcase of technology at the Pentagon and on the Hill. Each of the events is located on the campus of a public university.

#### INNOVATION

7. Senator BLACKBURN. Dr. Tompkins, what is the importance of Defense Innovation Unit (DIU) throughout combatant commands?

Dr. TOMPKINS. The DIU is an organization that accelerates capabilities across the joint force at speed, typically within a two-year time horizon. As is apparent in the current conflict in Ukraine and the pacing China threat, it is critically important to deliver capabilities to the combatant commands (CCMDs) at the speed of relevance.

Defense-relevant technologies increasingly originate in the commercial technology base, both in the U.S. and abroad. These dual-use technologies, including satellite imagery, drones, artificial intelligence, and communications tools, provide the CCMDs:

- Additional real-time tools to enable their missions;
- Unclassified opportunities to share information and ideas, particularly with allies and partners;
- Foreign partner modernization;
- A strengthened collective defense innovation landscape; and
- More robust interoperability among regional allies and partners.

8. Senator BLACKBURN. Dr. Tompkins, how is DARPA collaborating with academia and industries to provide innovative solutions for Space R&D?

Dr. TOMPKINS. DARPA is involved with a number of important lines of effort related to space. One significant one is DARPA's Blackjack program. The Blackjack program plans to launch a satellite demonstration of a proliferated low earth orbit (P-LEO) architecture leveraging commercial space technology. The Blackjack program aims to enable a cost-effective pivot away from large national space system satellites to proliferated networked satellites in polar or highly inclined low earth orbits. The proliferated architecture will enable critical warfighting strategic capabilities including deterrence (via numbers), resilience, global constant custody of enemy forces, and, most critically, the ability to rapidly introduce new warfighting technology to the space domain.

Additionally, Space-Based Adaptive Communications Node (Space-BACN) plans to leverage commercial space communication networks and technologies to enable more robust and efficient space-based communications. Since proliferated space is nascent, there is no standardization of communications or optical intersatellite link (OISL) specifications in this domain. Additionally, there is currently no means to bridge communications between disparate satellites and network constellations such as Starlink, OneWeb, and Blackjack. Space-BACN is a multi-standard optical terminal that can be reconfigured on-orbit to enable communications across different standards and connect these otherwise isolated constellations. The goal of Space-BACN is to enable the Government to easily connect to both Government and commercial satellites via high speed optical links enabling a "mega-constellation" for space-layer (or space-based) communications.

