NOT FOR PUBLICATION UNTIL RELEASED BY THE SUBCOMMITTEE

Statement by Dr. Peter Highnam

Deputy Director, Defense Advanced Research Projects Agency (DARPA)

Submitted to the
U.S. Senate Armed Services Committee
Subcommittee on Emerging Threats and Capabilities

Defense Innovation and Research

April 21, 2021

NOT FOR PUBLICATION UNTIL RELEASED BY THE SUBCOMMITTEE

Chairman Kelly, Ranking Member Ernst and Members of the Subcommittee, thank you for the opportunity to testify before you today. I am Peter Highnam, Deputy Director of the Defense Advanced Research Projects Agency, DARPA. It is a pleasure to be here with my colleagues representing their respective Services in the Department of Defense science and technology community. Our organizations work together every day to advance our Nation's defense technologies. DARPA's unique 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 capability.

For more than 60 years, DARPA has held to a singular and enduring mission: to make pivotal investments in breakthrough technologies for national security. Working with innovators inside and outside government, DARPA has repeatedly delivered on that 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, and Global Positioning System receivers small enough to embed in myriad consumer devices.

DARPA creates and executes programs that rely on and inspire an innovation ecosystem of academic, corporate, and government partners. We focus on developing capabilities for national security leaders and the nation's military services, who work with us to create new strategic opportunities and novel tactical options. For decades, this interlocking ecosystem of collaborators has proven to nurture intense creativity. 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 today is delivering on our most pressing security needs.

DARPA pursues game-changing technologies and capabilities in a way that provides surprising advantage for U.S. and Allied warfighters and at a much faster pace than the state of the art. DARPA's work with the Services and other agencies aims to meet not just known but as-yet unrecognized needs and move swiftly to deployment. That includes an increased emphasis on prototyping and joint projects – and, especially, a tighter emphasis on designing, building, and testing aspects of technology. Today, I will focus my testimony on how DARPA seeks to: 1) counter near-peer adversaries, 2) extend DARPA innovation to the warfighter and beyond, and 3) promote continued American innovation throughout the broader S&T ecosystem of university and industry partners.

1. Countering Near-Peer Adversaries

We seek to present adversaries with surprising warfighting scenarios that create dilemmas or completely disrupt their decision calculus. To do so, we must disrupt our own warfighting enterprises and provide decisive advantage across air, land, and sea, as well as space, cyberspace, and the electromagnetic spectrum. Big, monolithic platforms designed, built, and procured to do everything cost too much, take too long to field, and are usually technologically outdated by the time they are available. DARPA seeks a new asymmetric advantage – one that imposes complexity on adversaries by harnessing the power of dynamic, coordinated, highly autonomous, and flexible architectures.

A. New Warfighting Constructs

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) and Mosaic initiatives, along with their resulting technologies, seek to fundamentally change the way the military thinks about designing, buying, and deploying future systems.

First, the ABII program addresses several challenges posed by our near-peer 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 to 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 modelling and simulation environment to support analysis of true cross-domain (seafloor to space) cross-service warfighting constructs. Finally, the program is tying the advanced modelling and simulation environment 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 to both 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 the technical baseline for multi-domain operations moving forward.

In addition to ABII, DARPA has also 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 rapidly be tailored to accommodate available resources, adapt to dynamic threats, and be resilient to losses and attrition. Two Mosaic-related technologies – a novel decision aid for mission commanders and a rapid software integration tool – played a critical role in the recent Air Force demonstration of the Advanced Battle Management System (ABMS).

The Adapting Cross-domain Kill-webs (ACK) program and the System-of-systems Technology Integration Tool Chain for Heterogeneous Electronic Systems (STITCHES) were among a number of technologies employed late last summer in the ABMS on-ramp demonstration, which involved attacks using live aircraft, ships, air defense batteries, and other assets. ACK is developing a decision aid for mission commanders to assist them with rapidly identifying and selecting options for tasking – and re-tasking – assets within and across organizational boundaries. Specifically, ACK assists users with selecting sensors, effectors, and support elements across military domains (space, air, land, surface, subsurface, and cyber) that span the different military services to deliver desired effects on targets. Instead of limited, monolithic, pre-defined kill chains, these more disaggregated forces can be used to formulate adaptive “kill webs” based on all of the options available.

ACK was used in an air defense scenario during the ABMS demonstration, where an air commander faced incoming aerial threats and needed to quickly decide the best way to counter them. In the demo, the ACK decision aid software analyzed thousands of options to form cross-domain kill-webs and recommended assets and the best command-and-control "play" to the mission commander.

The machine-to-machine communications to enable this distributed fire control was performed by the STITCHES integration toolchain. STITCHES is a software-only and fully government owned (non-proprietary) toolchain specifically designed to rapidly integrate heterogeneous systems across any domain. STITCHES innovation is in auto-generating middleware between systems without needing to upgrade hardware or breaking into existing system software. The toolchain does not force a common interface standard; rather it rapidly creates the needed connections based on existing fielded capabilities obviating the need to upgrade in order to interoperate.

B. Responsive and Flexible Space Operations

The Department of Defense has prioritized rapid acquisition of small satellite and launch capabilities. Through leveraging commercial acquisition practices, DARPA has been able to streamline a number of militarily-relevant missions in the last year from conception through services acquisition and launch. These missions are validating emerging concepts for resilient architectures that would reside in low Earth orbit – an approach which will revolutionize communications, intelligence, surveillance, and reconnaissance.

Right now, satellites critical to our national security and warfighting capabilities traditionally are custom designed. In the increasingly contested space environment, these exquisite yet costly and monolithic systems have become vulnerable targets that would take years to replace if degraded or destroyed.

Meanwhile, the evolution of commercial space has led to the design and manufacturing of LEO constellations intended for broadband internet service, which could offer previously unavailable economies of scale. DARPA is interested in leveraging these advances through our Blackjack program and driving them forward in order to demonstrate military utility.

Blackjack aims to develop and demonstrate the critical technical elements for building a global high-speed network backbone in low Earth orbit. That would enable highly networked, resilient, and persistent DoD payloads that provide over-the-horizon sensing, signals, and communication, and hold the ground, surface, and air domains in constant global custody. To do that, researchers are investigating innovative vehicle delivery approaches that enable revolutionary advances in payload size, weight, power, and cost.

For Blackjack, we are targeting a series of risk reduction rideshare flights that will continue through this year. With these flights, the goal is to develop and validate the technologies to best position the Blackjack demonstrations.

C. Attribution of Malicious Cyber Actors

DARPA researchers are identifying and addressing critical cyber vulnerabilities that threaten global stability and security. Malicious actors in cyberspace currently operate with little fear of being caught due to the fact that it is extremely difficult, in some cases perhaps even impossible, to attribute malicious actions in cyberspace to specific individuals. The reason cyber attribution is difficult stems at least in part from a lack of end-to-end accountability in the current internet infrastructure.

To address this problem, DARPA launched the Enhanced Attribution (EA) program. EA is making currently opaque malicious cyber adversary actions and individual cyber operator attribution transparent by providing high-fidelity visibility into all aspects of malicious cyber operator actions. Furthermore, if successful, EA will increase the government's ability to publicly reveal the actions of individual malicious cyber operators without damaging sources and methods. Over the last three years the program has developed techniques and tools for generating operationally and tactically relevant information about multiple concurrent independent malicious cyber campaigns, each involving several operators, and the means to share such information with US. law enforcement, intelligence, and Allied partners.

Late last year, DARPA EA researchers used their data analytics to develop timely, accurate threat information regarding Russian-attributed malicious cyber infrastructure and associated actor personas. EA shared this information with close partners at the FBI Atlanta and Pittsburgh field offices, contributing to the October 2020 indictment of six GRU personnel associated with a worldwide destructive malware campaign and the remediation of that malware campaign in U.S. and Allied critical infrastructure.

D. Hypersonics

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 advantages on the tactical battlefield, especially for conducting military operations from longer ranges, with shorter response times, and enhanced effectiveness compared to current military systems.

DARPA is developing technology demonstrations in 2021 for a number of operational capabilities. For example, the Hypersonic Air-breathing Weapon Concept (HAWC) program is a joint effort with the U.S. Air Force (USAF) seeking to develop and demonstrate critical technologies to enable an effective and affordable air-launched hypersonic cruise missile. The program emphasizes efficient, rapid, and affordable flight tests to validate key technologies. HAWC is pursuing flight demonstrations to address three vital technology challenge areas: air vehicle feasibility, effectiveness, and affordability.

The Tactical Boost Glide (TBG) program is another joint DARPA/USAF undertaking, striving to develop and demonstrate technologies to enable future air-launched, tactical-range hypersonic boost glide systems. In such systems, a rocket accelerates its payload to high speeds, the payload then separates from the rocket, and glides unpowered to its destination. TBG plans to include ground and flight-testing in 2021 to mature critical technologies and demonstrate system performance.

2. Innovations for the Warfighter and Beyond

A. Stopping Pandemics

A primary aim of the DARPA Biological Technologies Office (BTO) is to improve total force health protection and readiness. One of the biggest vulnerabilities to deployed military personnel and civilians is a lack of protection against many endemic and emerging bio-threats (e.g., the ongoing COVID-19 pandemic, or mosquito-borne viruses such as Chikungunya and Dengue).

DARPA's approach to pandemic prevention advanced the current state of the art by enabling antibody discovery in days to weeks rather than months to years. Additionally, DARPA investments in new diagnostic platforms allowed researchers to pivot rapidly to emergent viruses such as COVID-19. In 2011, DARPA began investing in gene-encoded vaccines based on DNA or RNA. Unlike traditional vaccines, which nearly all require laborious, expensive, and lengthy development times to counter each new threat, gene-based vaccines have the advantage of directly delivering coded genetic instructions to the body on how to produce its own protective antibodies against a specific threat. This means gene-encoded vaccines can be easily manufactured at scale using largely synthetic processes, versus being cultured in eggs; transported and stored without many of the cold-chain logistics required by traditional medical countermeasures; delivered with near-immediate efficacy; and safely expressed in the body for only a limited duration, causing no permanent alteration to the genome. This approach has shown great promise as a means to provide safe, reproducible, long-term immune protection. However, vaccines often require more than one dose and weeks to months before protected status is achieved, creating vulnerability either directly to warfighters if they are deployed before immunity has been established or to the mission due to the delayed deployment of personnel until they achieve immune protection.

DARPA's fundamental research and development (R&D) investments, fortunately, have resulted in discovery of several gene-encoded monoclonal antibody platforms, and has greatly de-risked the gene-based medical countermeasure (MCM) field. DARPA R&D investments have catalyzed significant commercial and transition interest. Several companies (including Moderna, AstraZeneca, and Inovio) have made major investments in the budding field of gene-encoded MCMs and have released vaccines to curb the spread of COVID-19. DARPA investments also spurred spin-out companies such as RenBio, which is optimizing the delivery of gene-based MCMs for increased efficacy and tolerability.

Early in 2020, DARPA allied closely with department medical and chem/bio defense organizations as well as Health and Human Services (HHS) components to join the fight against COVID-19. Many of these intergovernmental allies – including the DoD's Joint Program Executive Office for Chemical and Biologic Defense (JPEO CBD), the HHS Biomedical Advanced Research and Development Authority (BARDA), and the HHS National Institute of Allergy and Infectious Disease (NIAID) – partner with DARPA to perform advanced development after our initial investments, ensuring the scale-up and distribution of novel medical countermeasures.

Building on existing DARPA investments to accelerate the discovery of novel countermeasures, DARPA-funded researchers were responsible for discovering therapeutics – antibodies – from blood samples of recovered coronavirus patients. DARPA also partnered with advanced developers (public and private) to manufacture at scale using DNA/RNA techniques in addition to traditional cell-based bio-manufacturing.

B. Extending the "Golden Hour"

When a Service member suffers a traumatic injury or acute infection, the time from event to first medical treatment is usually the single most significant factor in determining the outcome between life and death. First responders must act as quickly as possible, first to ensure a patient's survival and then to prevent permanent disability. The Department of Defense refers to this critical, initial window of time as the "golden hour," but in many cases the opportunity to successfully intervene may be less than sixty minutes, which is why the military invests so heavily in moving casualties as rapidly as possible from the battlefield to suitable medical facilities. However, due to the realities of combat, there are often hard limits to the availability of rapid medical transport and emergency care.

DARPA created the Biostasis program in 2018 to develop new possibilities for extending the golden hour, not by improving logistics or battlefield care, but by going after time itself, at least how the body manages it. Biostasis is attempting to address the need for additional time in continuously operating biological systems faced with catastrophic, life-threatening events. The program leverages molecular biology to control temporarily the speed at which living systems operate, and thus extend the window of time following a damaging event before a system collapses. Essentially, the concept aims to slow life to save life.

C. Serving Wounded Veterans

With a focus on wounded warriors and facilitating their return to military service, the Hand Proprioception and Touch Interfaces (HAPTIX) program is pursuing key technologies to enable precision control of and sensory feedback from sensor-equipped upper-limb prosthetic devices. If successful, the resulting system would provide users near-natural control of prosthetic hands and arms via bi-directional peripheral nerve implants. The program has a strong focus on technology transition and aims to create clinically relevant technology in support of wounded warriors suffering from single or multiple limb loss.

HAPTIX builds on prior DARPA investments in the Reliable Neural-Interface Technology (RE-NET) program, which created novel neural interface systems that overcame previous sensor reliability issues (sensors now last for the lifetime of the patient). A key focus of HAPTIX is on creating new technologies to interface permanently and continuously with the peripheral nerves in humans. HAPTIX researchers are designing technologies to tap into the motor and sensory signals of the arm to allow users to control and sense the prosthesis via the same neural signaling pathways used for intact limbs. Direct access to these natural control signals will, if successful, enable more natural, intuitive control of complex hand movements, and the addition of sensory feedback will further improve prosthetic hand functionality by enabling users to sense grip force and hand posture. Sensory feedback may also provide important psychological benefits such as improving prosthesis "embodiment" and reducing the phantom limb pain that is suffered by approximately 80 percent of amputees.

In addition to seeking to return sensation to amputees, DARPA is also aggressively investigating technical solutions to spinal cord injury (SCI), which is of significant concern to the Department of Defense. Of the 337,000 Americans with serious SCIs, approximately 44,000 are veterans, with 11,000 new injuries occurring each year. SCI is a complex condition – the injured often face lifelong paralysis and increased long-term morbidity due to factors such as sepsis and autonomic nervous system dysfunction. While considerable research efforts have been devoted toward restorative and therapeutic technologies to SCIs, significant challenges remain.

DARPA's Bridging the Gap Plus (BG+) program aims to develop new approaches to treating SCI by integrating injury stabilization, regenerative therapy, and functional restoration. Last year, DARPA announced the award of contracts to a handful of university researchers to advance this crucial work. Multidisciplinary teams at each of these universities are tasked with developing systems of implantable, adaptive devices that aim to reduce injury effects during early phases of SCI, and potentially restore function during the later chronic phase.

3. Promoting American Innovation

One of the classic models of technology development begins with basic research that uncovers a new principle or phenomenon, which innovators then apply and develop into a new capability that enables people to do more than they could before. 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. Indeed, 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 big part of DARPA's expertise is seeking high pay off capabilities by managing risk in ways that help keep the innovation pipeline flowing. The following are examples of the kinds of foundational efforts that promise to impact national security just like other DARPA "firsts," including the ARPAnet, miniaturized GPS, stealth aircraft, UAVs, and monoclonal antibody therapeutics.

A. Artificial Intelligence

DARPA has been a leader in artificial intelligence since the 1960s. We 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 pursing more than 30 programs that are exploring ways to advance the state-of-the-art in AI, pushing beyond second-wave machine learning techniques towards contextual reasoning capabilities. In addition, more than 60 active programs are applying AI in some capacity, from agents collaborating to share electromagnetic spectrum bandwidth to detecting and patching cyber vulnerabilities.

Under the AI Next campaign, key areas being explored include automating critical DoD business processes; 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 announced a quick-turn funding mechanism called Artificial Intelligence Exploration (AIE) that allows us to quickly 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 in as little as 90 days of up to $1 million each for 18-month periods of performance. During these periods of performance, very high-risk, high-reward topics will be investigated with the goal of determining feasibility and clarifying whether the area is ready for increased investment. The ultimate goal of each AIE Opportunity is to invest in research that leads to prototype development that may result in new, game-changing AI technologies for U.S. national security. To date, we have made 141 contract awards for more than 20 AIE topics.

A representative example of DARPA's AI Next campaign is the Assured Autonomy program, which is working to provide continual assurance of a learning-enabled cyber physical system's (LE-CPS) safety and functional correctness. The program is developing mathematically verifiable approaches and tools that can be applied to different types and applications of data-driven machine learning algorithms in an LE-CPS to enhance their autonomy and assure they are achieving an acceptable level of safety. To help ground the research objectives, the program is prioritizing challenge problems in the defense-relevant autonomous vehicle space, specifically related to air, land, and underwater platforms.

To assess the technologies in development, research teams integrated them into a small number of autonomous demonstration systems and evaluated each against various defense-relevant challenges. After 18 months of research and development on the assurance methods, tools, and learning enabled capabilities (LECs), the program is exhibiting early signs of progress.

During a recent demonstration, DARPA researchers integrated tools with an Iron Bird X-Plane simulation and a small test bed aircraft, and tested them against challenge problems relevant to ground operations, specifically assuring taxi operations on an airfield or aircraft carrier deck.

During the live aircraft exercise, the assurance methods were able to detect the presence of an obstacle during taxi, which triggered a safety that identified and executed a response route around the obstacle. The assurance methods also detected when the camera feed was being noised or obscured, kicking-in a safety method that identified and executed what it deemed the safest response – stopping the aircraft until it could safely resume operations. Additionally, the tools were able to detect anomalies that could cause their LEC to misbehave, and allowed the system to maintain safe operations despite those anomalies. Further, the use of formal models and specifications provided assurances about the system's safety both at design and run time.

B. Microelectronics

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 about every two years. 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 aims to forge 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 benefitted 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 envisions four key areas of development – 3D heterogeneous integration, new materials & devices, specialized functions, and design & 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 to both 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. Several technological advancements developed in the DARPA CHIPS, PIPES, and HI3 programs are in transition leveraging SOTA commercial manufacturers in the OUSD(R&E) the State-of-the-art (SOTA) Heterogeneous Integrated Packaging (SHIP) program. This is a critical microelectronics performance enabler for DoD modernization priorities, including hypersonics, Artificial Intelligence, 5G, Cyber, and Space.

C. 5G Networks

Emerging 5G mobile wireless networking technologies are slated to dramatically increase in both scale and speed, enabling much faster access to data collected from billions of connected devices (~60 billion nodes by 2023). This supercharged information highway is envisioned to play an important role across many industries, ranging from medicine to manufacturing. Major advances in 5G will make it easier to customize the network at a wide variety of locations. This new flexibility offers many benefits, but at the same time introduces novel security challenges. Today's proprietary 5G technologies make it difficult to achieve the transparency necessary for security-related risk analysis and mitigation. This lack of security assurance makes it harder to deploy these technologies for defense capabilities.

In 2020, DARPA created the Open, Programmable, Secure 5G (OPS-5G) program to tackle many of the security challenges facing future wireless networks. OPS-5G is exploring the development of a portable, standards-compliant network stack for 5G mobile networks that is open source, and secure by design. The program seeks to enable a “plug-and-play” approach to various network software and hardware components, which reduces reliance on untrusted technology sources. OPS-5G will also explore the development of cost-effective SWaP-conscious cryptography with scalable security protocols. Overall, the goal of OPS-5G is to enable more secure 5G as well as future generations of networks beyond 5G.

D. Quantum Information Science

Quantum information science (QIS) includes computation, communication, and sensing technologies that exploit our understanding of quantum mechanics. Theory promises significant advances over the state of the art, with some practical successes, but much of the QIS field remains technically nascent. The successes are largely related to sensors that deliver exquisite sensitive measurements in small packages. For the DoD, this supports RF devices for radar and communications, it also enables precise stable measurement of time – useful for communication and for navigation. Much has been published on the use of quantum technology for secure communications, a technical area that saw successful DARPA investments over a decade ago. The capabilities promised by theorists for quantum computation have been more elusive. The notion of a quantum computer that can outperform conventional computers to solve useful problems is attractive, but in practice has not been possible to achieve.

DARPA is currently pursuing basic and applied QIS research. One program aims to produce small portable devices that maintain GPS-quality time and position for weeks – in the absence of GPS signals. Another program seeks to understand what may be the limits of electromagnetic sensing using clouds of atoms. Several programs explore aspects of quantum computation to determine which approach offers the most promise for substantial practical advantage. These computation efforts include two of note: how to use a moderate number of imperfect quantum bits, while another seeks to bring rigor to the fledgling quantum computing marketplace with the introduction of insightful benchmarking. There is much valuable science that quantum-based computation may make possible in diverse fields including material science, machine learning, and biology, but it remains a DARPA-hard field in which to work.

E. Nurturing the Innovation Base

Over the past two years, DARPA’s Embedded Entrepreneurship Initiative (EEI) pilot program has helped 30 pre-seed research teams raise over $100 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 February of this year, 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. The initiative augments technical research teams with critical entrepreneurial expertise, top-tier commercialization mentors, and provides connections to investors. This important work helps to counter aggressive foreign investors by building stronger companies that have the ability to attract U.S. capital.

In this effort, DARPA is teaming with IQT Emerge, a new organization within In-Q-Tel (IQT) that provides entrepreneurial expertise as well as connections to early-stage U.S. investors. IQT Emerge leverages IQT’s unique place at the intersection of venture capital, government, and the startup community to keep the national security community at the forefront of technology innovation.

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 obtain the full benefit from taxpayer funded R&D investments.

Since 2018, roughly the same time frame from the inception of EEI, DARPA has also stepped up its outreach to university researchers. Security concerns in recent years have significantly increased the barriers to university research for the DoD, and better communication of opportunities and expectations is critical to minimizing those barriers. DARPA's academic outreach initiative began in earnest with visits to a handful of public universities. During the pandemic, however, the agency was forced to change tactics and hosted a large virtual event in September 2020 called the "DARPA Vice Presidents and Chancellors of Research Summit." The Summit attracted 223 representatives from 126 schools across the nation; twenty percent of the schools had never done business with the agency. During the three-hour summit, participants learned about the agency's near-term investment priorities and how to pursue funding opportunities through existing contract vehicles.

In addition to small business and university outreach efforts currently underway, DARPA also has three formal programs aimed at supporting the next generation of researchers. The first effort is the Joint University Microelectronics Program (JUMP). JUMP is a major public/private initiative that includes several leading companies from the semiconductor and defense industries such as Intel, IBM, Micron, Analog Devices, EMD Performance Materials, ARM, Samsung, TSMC, Raytheon, Northrop Grumman, and Lockheed Martin who have tasked six research centers to undertake high-risk, high-payoff research that addresses existing and emerging challenges in microelectronic technologies. JUMP comes at an inflection point in the history of the semiconductor industry where application and system research are critical to enabling the development of superior electronic systems to meet DoD and commercial needs.

Under JUMP, the challenges of the "application-centric" research centers focus on accomplishing application-oriented goals and spurring the development of complex systems with capabilities well beyond those available today. Diving deep into cognitive computing, intelligent memory and storage, distributed computing and networking, and radio frequency (RF) to terahertz (THz) sensor and communications systems, among other areas, these research centers are developing systems that will be transferable to military and industry in a five year timeframe and ready for field deployment in ten years.

Also, earlier this year, DARPA announced a post-doctoral fellowship program for talented young scientists, engineers, and mathematicians in the field of computer science with grants sized to support each fellow for up to two years. Participation in DARPA's new program is open to current U.S. citizens and permanent residents who have received a Ph.D. degree no earlier than June 2019 or who will have received a Ph.D. prior to the date of award, and who will be appointed to a postdoctoral position at a U.S. institution of higher education during the 2021-22 academic year.

The longest running program that DARPA has supporting university researchers is the Young Faculty Awards (YFA), which has been providing funding opportunities since 2006 as a forward-looking way to familiarize rising researchers in junior positions with national-security-relevant work within the DoD. The YFA program provides funding, mentoring, as well as industry and DoD contacts to awardees early in their careers with the long-term goal of developing the next generation of academic scientists, engineers, and mathematicians who will focus a significant portion of their career on national security issues. To date, 447 researchers from 40 states have participated in the YFA program.

Conclusion

From DARPA's perspective, the technological future – the endless frontier - is enormously attractive, bright with opportunities, but also fraught with unanticipated risks. For more than 60 years, the men and women of DARPA have taken very seriously their unique mission to serve the Nation by preventing – and when necessary fomenting – technological surprise.

Although I have just recently returned 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 historic 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.