Statement by Dr. Steven Walker
Director, Defense Advanced Research Projects Agency

Before the
Subcommittee on Emerging Threats and Capabilities
Armed Services Committee, U.S. House of Representatives

A Review and Assessment of the Fiscal Year 2019 Budget Request for Department of Defense Science and Technology Programs

March 14, 2018

Introduction

For 60 years, DARPA has held to a singular and enduring mission: to make consequential investments in breakthrough technologies for national security. The genesis of that mission and of DARPA itself dates to a commitment by President Eisenhower that the United States would be the initiator of strategic technological surprise. Working with innovators inside and outside of government, DARPA has repeatedly delivered on that mission, transforming revolutionary concepts and even seeming impossibilities into practical capabilities. The ultimate results have included not only game-changing military capabilities such as precision weapons and stealth technology, but also features of modern civilian society such as the Internet, automated voice recognition and language translation, and Global Positioning System receivers small enough to embed in mobile consumer devices.

DARPA explicitly reaches for transformational change instead of incremental advances, but it does not perform its engineering alchemy in isolation. It works within an interlocking ecosystem of diverse collaborators that includes academic, corporate and governmental partners with the collective goal to create innovative strategic opportunities and novel tactical options.

In the six decades since DARPA was established, the world has changed dramatically—and the rate at which those changes have occurred has in many respects increased. Those changes include some remarkable and even astonishing scientific and technological advances that, if wisely and purposefully harnessed, have the potential not only to ensure ongoing U.S. military superiority and security, but also to catalyze societal and economic advances. At the same time, the world is experiencing deeply disturbing technical, economic, and geopolitical shifts that pose potential threats to U.S. preeminence and stability. These dueling trends of unprecedented opportunity and risk deeply inform DARPA's most recent determination of its strategic priorities.

Accordingly, the following testimony includes relevant details about: **1)** DARPA's strategic priorities placed within their global context; **2)** how DARPA is accelerating new technologies to meet emerging threats, and, finally, **3)** components of the agency that are central to the identification of emerging threats as well as the successful transition of future capabilities.

Determining Strategic Priorities in a Global Context

Since the beginning of the year, President Trump has released the National Security Strategy (NSS) and Secretary Mattis has released the National Defense Strategy (NDS). These are two very important documents

for the country and there are strong ties between them and where DARPA is heading. The common theme in the NSS, NDS, and DARPA's strategy is a focus on threat-based mission scenarios. To address myriad threats to national security, DARPA is working to achieve new, revolutionary capabilities based on four focus areas:

- ***Defending the homeland*** from varied threats includes developing cyber deterrence capabilities, bio-surveillance and biothreat defense techniques, and the ability to sense and defend against weapons of mass terror/destruction.
- ***Deterring and prevailing against peer competitors*** in Europe (a stand-in scenario) and in Asia (a stand-off scenario) requires new thinking. The U.S. can no longer be dominant across all scenarios, but it needs to be highly lethal in select ones. This lethality needs to be surprising to peer competitors. Realizing new capabilities across the land, sea, and air domains is important, but space and the electromagnetic spectrum are just as important.
- ***Effectively prosecuting stabilization efforts across the globe*** requires us to get better at fighting differently and in different environments. Capabilities to address gray-zone conflict and 3D city-scale warfare, along with the development of rigorous and reliable models to predict adversarial moves prior to engagement, are critical.
- ***Foundational research*** in science and technology underlies all of DARPA's grander pursuits and is what makes possible never-before-seen capabilities. Ultimately, the goal of the agency's fundamental R&D investments is to ensure that U.S. warfighters have access to the most advanced technologies. Research funded by DARPA in the near term explores science and technology that will lead to "leap ahead" solutions for specific current and future challenges to military readiness across multiple operational domains.

Accelerating new technologies to meet emerging threats

The cycle of innovation at DARPA is alive and well today—though the agency's approach to developing breakthrough technologies has evolved with advances in the larger U.S. innovation ecosystem. Increasingly, DARPA is taking advantage of the extraordinary creativity and pace of the private commercial sector and then adding customized Government-developed components to create specialized military tools and capabilities more precise and powerful than anything available elsewhere in the world.

Defend the Homeland

The principal task of the Department of Defense is to defend the Nation and its interests around the world. So too is defense the raison d'être for DARPA. The following section highlights recent DARPA developments at various stages of transition. Together, these advances represent a portfolio of progress that promises to keep the Nation secure while DARPA's innovators extend the agency's reach to new and even more exciting technological frontiers.

Detecting Radiological Threats Before It's Too Late

Perhaps no domestic security threat today exceeds that of a nuclear or radiological "dirty bomb" detonation. Current sensors can detect high-emitting radiological materials that could signal such mass-terror devices, but are too large and expensive to deploy widely to fully protect an urban area or major transportation hub.

DARPA's SIGMA program has successfully created high quality, handheld radiological sensors—the size of an average smart phone—at a fraction the cost of today's devices. SIGMA developed not only that hardware but also the software to monitor thousands of those mobile detectors in real time—an essential capability to discern the movement of nuclear materials before they can be incorporated into a terrorist's weapon.

In collaboration with officials in the Washington, D.C., metropolitan area and the Port Authority of New York and New Jersey, DARPA in 2016 tested the devices and networking system at critical transportation hubs and on a city-wide scale involving 1,000 detectors. That test showed the system could fuse the data provided by all those sensors to create minute-to-minute situational awareness of nuclear threats. Working in close cooperation with the Department of Homeland Security, DARPA's technology has been on track for deployment in multiple locations. Also, DARPA is now looking at expanding SIGMA's capabilities to include threat detection for other harmful elements such as chemicals, explosives, and biological and radiological agents.

Defending the Worlds' Largest Network

Another research effort DARPA is working on that is already contributing to national security is called Network Defense. The program, which launched in 2015, sifts through terabytes and terabytes of Department of Defense Information Network (DODIN) data to sniff out harmful network events. Each month, DODIN users generate an order-of-magnitude more data than existing analysis capabilities can possibly process. To address this analytical deficit, DARPA recently transitioned elements of its Network Defense program to the United States Cyber Command. Working with members of the Army's Cyber Protection Teams (CPTs) as well as U.S. CYBERCOM, DARPA researchers were able to identify three Advanced Persistent Threats (APT) domains within the first few days of operation. As the program progressed, more than five crime-ware infections were discovered and several other network anomalies were referred for more detailed investigation.

Network Defense has also produced results for commercial transition partners. In late 2016, DARPA researchers identified a botnet, in addition to an insider threat, attacking a Fortune 500 partner. In all, Network Defense researchers developed more than 44 scalable mathematical techniques that are currently applied in commercial and military contexts, uncovering, to date, in excess of 60 cybersecurity exploits.

The SIGMA and Network Defense programs are just two representative samples of how DARPA is working with its government partners to defend the homeland from attack. In the next section, other program examples show more lethal options the Nation will soon have at its disposal to both deter and prevail against high-end adversaries.

Deter and Prevail Against Peer Adversaries

To present adversaries with surprising warfighting scenarios that create dilemmas within or completely disrupt their decision calculus, we must disrupt our own warfighting enterprises and provide for adaptive lethality across the physical domains of air, land, and sea. Big monolithic platforms that are designed, built, and procured to do everything cost too much, take too long to field, and are usually technologically out of date by the time they are fielded. DARPA seeks a new asymmetric advantage—one that imposes complexity on adversaries by harnessing the power of dynamic, coordinated, highly autonomous, and flexible architectures.

Delivering Long-Range Anti-Ship Capabilities

One example of a flexible, semi-autonomous capability, is the Long Range Anti-Ship Missile (LRASM), which was developed jointly by DARPA and the Office of Naval Research (ONR) and began in 2009. LRASM is a precision-guided, survivable standoff missile that will protect U.S. Navy surface ships in a highly contested environment. After successful initial flight tests by DARPA and ONR, DARPA stood up a rapid deployment office with the Navy and Air Force, located within the agency's headquarters, to insure a seamless and speedy leap to operational capability this calendar year.

Hypersonics

Our ability to field hypersonic systems constitutes another arena of national defense that DARPA is pursuing aggressively and with a particular sense of urgency due to the rising pace of related research by peer adversaries. Hypersonic flight—which refers to flight velocities of more than five times the speed of sound—offers a number of strategic advantages. Namely, the potential for military operations from longer ranges with shorter response times and enhanced effectiveness compared to current military systems.

Looking beyond the early investigative stages of the program, DARPA is now developing hypersonic technology demonstrations for operational capabilities. Those demonstrations are on schedule to occur in late 2019, and the agency, working with the Air Force, is putting in place a "LRASM-like" transition activity to develop a hypersonic weapon early operational capability. Additional FY19 funds for DARPA's hypersonics programs will allow the agency to bring on additional resources to add more flights and do more evaluation prior to a hand-off to the Air Force.

Effectively prosecuting stabilization efforts

DARPA's mission is to look beyond the reality of today and to focus on the potentiality of the future. Specifically, its job is to identify current or future advances that have the potential to bend today's security trajectories— advances that, years from now, could disrupt the stability the country enjoys as well as advances that, over the same period, could enhance national and global stability.

Invariably, stabilization efforts also require U.S. soldiers to be on the ground to remove threats and project strength. That, of course, requires putting American lives in danger. As an agency with vast technical means and know how, DARPA sees it as a moral obligation to attend to and roundly improve all aspects of warfighter performance.

Squad X Core Technologies (SXCT)

To succeed in their missions, military units must have a robust, multi-faceted picture of their operational environments, including the location, nature, and activity of threats and allied forces around them. Technology is making this kind of rich, real-time situational awareness increasingly available to airborne and other vehicle-assigned forces, along with a capacity to deploy precision armaments more safely, quickly, and effectively. Dismounted infantry squads, however, have so far been unable to take full advantage of some of these highly effective capabilities because many of the technologies underlying them are too heavy and cumbersome for individual Soldiers and Marines to carry or too difficult to use under demanding field conditions.

DARPA's Squad X Core Technologies (SXCT**)** program is currently developing novel technologies that could be integrated into user-friendly systems that would extend squad awareness and engagement capabilities without imposing physical and cognitive burdens. The goal is to speed the development of new, lightweight, integrated systems that provide infantry squads unprecedented awareness, adaptability, and flexibility in complex environments, and enable dismounted Soldiers and Marines to more intuitively understand and control their complex mission environments.

Foundational Research and Technologies

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 to the point of "implausible and then, surprisingly, possible." No other agency within the Defense Department 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. Indeed, a big part of DARPA's particular expertise is seeking high-pay off capabilities by managing risk in ways that help keep the innovation pipeline flowing. In the previous section, several

existing programs were detailed, below, however, we will explore new, foundational-research efforts that promise to impact national security like the ARPAnet and Have Blue.

One of these foundational technology areas is advanced electronics. DARPA has had a key role over the years in advancing the state of the art in electronics, especially in the semiconductor space. Today, the advanced electronics industry is at an inflection point. Design work and fabrication now required to keep on pace is becoming ever more difficult and expensive, and the pace of homegrown innovation is slowing while countries such as China—which is significantly behind the U.S. and others in semiconductor capability now—are investing huge sums of government-directed private capital to acquire on-shore semiconductor design and manufacturing capabilities.

Electronics Resurgence Initiative

In 2017 DARPA launched the Electronics Resurgence Initiative (ERI), which aims to create "leap ahead" technology that will marginalize traditional circuit technology and create a wave of new U.S. development and economic opportunity. Over the next four years, ERI will commit hundreds of millions of dollars to nurture research in advanced materials, circuit design tools, and new system architectures.

The foundation for the Initiative has been building for a number of years in the form of existing MTO programs. Another major ERI component is an extensive university-based program—the Joint University Microelectronics Program (JUMP)—that MTO and corporate partners have organized to build up a fundamental research base in fields underlying microelectronic technologies. Corporate partners include ARM, IBM, Intel, Lockheed Martin, Northrop Grumman, Raytheon, and Samsung, among others.

Safe Genes

From electrons to genes, DARPA recognizes that the current pace of scientific progress at the fundamental level poses both challenges and opportunities. That is, in large part, why DARPA created the Safe Genes program—to gain a basic understanding of how gene editing technologies function; devise means to safely, responsibly, and predictably harness them for beneficial ends and address potential health and security concerns related to their accidental or intentional misuse.

Achieving such ambitious goals requires more complete knowledge about how gene editors, and derivative technologies including gene drives, function at various physical and temporal scales under different environmental conditions, across multiple generations of an organism. In parallel, demonstrating the ability to precisely control gene edits, turning them on and off under certain conditions or even reversing their effects entirely, will be paramount to the safe translation of these tools to practical applications.

Explainable Artificial Intelligence

The deliberate and safe exploration of revolutionary technologies is a common theme at DARPA. Where there is bluster, hype, and uncertainty surrounding new innovations, DARPA cuts through to find the ground truth. This is evident in the agency's approach to gene editing and in the burgeoning field of artificial intelligence. For more than four decades DARPA has been driving artificial intelligence research, deftly separating science from science fiction. Early "first-wave" research by the agency resulted in expert systems, powerful ways to interact with computers, knowledge representation used in electronic commerce, enhanced operational planning tools, industrial robots, and self-navigating vehicles. We are now entering the "second wave" in which machine learning techniques, powered by inexpensive computing, has produced breakthroughs in broad areas of our everyday experience, including interaction with computers, language translation, image and video analysis, and the beginning of autonomous vehicles for consumers. DARPA's vision, focus, and funding made this possible.

DARPA is now framing and leading the "third-wave" of AI, in which contextual reasoning, the ability to effectively convey to human users how and why specific decisions are made. DARPA is also advancing the theory of AI to ensure that systems are robust and efficient as the technology is embedded within critical systems across society. The program at the center of this push is called Explainable AI or XAI.

Recognizing that the Department of Defense is facing challenges that demand more intelligent, autonomous, and symbiotic systems, XAI aims to create a suite of machine learning techniques that produce explainable models, while maintaining a high level of prediction accuracy so human users understand, appropriately trust, and effectively manage the emerging generation of artificially intelligent partners. Through XAI, new machine-learning systems will have the ability to explain their rationale, characterize their strengths and weaknesses, and convey an understanding of how they will behave in the future.

As the above highlights reveal, powerful technology trends are fueling many of DARPA's programs. Other areas where the agency is making investments include: materials, human-machine symbiosis, rapid access to space, autonomous systems, weapons effects, encryption, and more.

Keys to Success

In order to attend to the myriad threats and challenges posed to the Nation, DARPA remains committed to the principles that have garnered it success for sixty years. First and foremost, DARPA is a projects agency. The agency starts projects *and*, if prudent, stops projects; it insists on metrics and milestones to measure progress; and if DARPA's researchers prove something audacious can be done, then it very well may have the potential to gird our security position and even change the world. As such, DARPA will continue to use rigorous, time-tested methods—unique to the agency—to ensure it initiates and shepherds programs that anticipate future threats and make significant contributions to national security.

DARPA projects address the highest payoff, highest risk, and most forward-looking technology concepts in deciding what investments might have the most significant impact in addressing future national security challenges. DARPA investments seek to address seemingly impossible technical barriers in demonstrating "proof of concept" for solutions to these challenges. This model has a distinguished track record of producing answers to future questions that span operational environments while sometimes leading to applications in the commercial sector.

The next guiding principle of DARPA is strong partnerships with others in the science and technology ecosystem, including the Services, defense companies, small and large commercial entities, startups, allied nations, academics, and our stakeholders in the executive and legislative branches of government. DARPA cannot do what it does as an agency without support from these elements, as noted above in program examples like ERI and the agency's hypersonics research. The new leadership team at DARPA is actively meeting with and strengthening relationships with senior military leadership—relationships based on trust and performance—with the goal of showing how the agency can take ideas perceived to be impossible and make them possible.

Finally, the third priority in this 60th year of DARPA, is continuing to ensure we have the best and most creative people in the world. DARPA comprises approximately 220 government employees in six technical offices, including nearly 100 program managers, who together oversee about 250 research and development programs. This small group of uniquely dedicated people represent the talent responsible for maintaining acute awareness of emerging technology trends and capitalizing on them before others do.

DARPA goes to great lengths to identify, recruit, and support extraordinary program managers who are at the top of their fields and are hungry for the opportunity to push the limits of their disciplines. These leaders, who are at the very heart of DARPA's history of success, come from academia, industry and government agencies for limited stints, on average, of just three to five years. That inherent sense of deadline fuels the

signature DARPA urgency to achieve success in less time than might be considered reasonable in a conventional setting.

Program managers address challenges broadly, spanning the spectrum from deep science to systems to capabilities, but ultimately they are driven by the desire to make a difference to national security. They define their programs, set objectives, meet with their performers, and assiduously track progress. All the while, they are probing for the next big thing in their fields by engaging as peers with leaders in the scientific and engineering community to identify new challenges and potential solutions.

The DARPA team is one whose collective energy not only propels the agency, but also invigorates and inspires people across the wider community with which it works—defense companies large and small, commercial startups, universities, government agencies and labs, and our close partners across the Department of Defense. The DARPA team revels in the opportunity to attack pressing and previously intractable problems—all in the context of public service.

Conclusion

DARPA focuses every day on assuring the success of its individual programs. But the ultimate objective of the agency's work is the achievement of major, unexpected advances in national security capabilities. DARPA's record in this regard is unrivaled. Precision-guided munitions, stealth technology, unmanned systems, advanced ISR, and infrared night vision have individually and together induced remarkable changes in how U.S. forces fight and win. At the same time, the enabling technologies behind these military capabilities—new materials, navigation and timing devices, specialized microelectronics, advanced networking and artificial intelligence, among others—helped lay a foundation for private-sector investments that extended far beyond the battlefield to create products and services that have changed how people live and work. In a further amplification of impact, these sophisticated commercial products and services are themselves being harnessed by DARPA and other DoD agencies to advance national security and ensure military advantage.

As DARPA looks to its next 60 years, it promises to continue to be a bold, risk-tolerant investor in high-impact technologies so the Nation can be the first to develop and adopt the novel capabilities made possible by such work. DARPA is deeply committed to this mission in the furtherance of national security, and with continued support from Congress, as well as the backing of the Pentagon and partners in the broader S&T ecosystem, it will succeed.