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Department of Defense (DOD) Fiscal Year 2016 Science and Technology Programs: Laying the Groundwork to Maintain Technological Superiority

Statement by Dr. Arati Prabhakar

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Chairman Wilson, Ranking Member Langevin and Members of the Subcommittee, thank you for the opportunity to testify before you today. I am Arati Prabhakar, Director of the Defense Advanced Research Projects Agency, better known as DARPA. It is a pleasure to be here with my colleagues from across the Department of Defense (DoD) Science and Technology (S&T) community, with whom we in DARPA work every day to advance our Nation's defense technologies. DARPA plays a particular role in this community, and in the broader U.S. technology ecosystem. That role is to anticipate, create and demonstrate breakthrough technologies that hold the potential for extraordinary advances in national security capability. It is a mission that dates to the launch of Sputnik in 1957 and a commitment by the United States that, from that time forward, it would be the initiator and not the victim of strategic technological surprises.

That mission, our current work and our plans for the coming years are the focus of my testimony today. But the short version of that story is that the people of DARPA come to work every day to extend the Agency's historic role by working with innovators inside and outside of government to transform revolutionary concepts—and even seeming impossibilities—into practical capabilities. Our record speaks volumes about our capacity to succeed. The ultimate results of past work by DARPA include not only game-changing military capabilities such as precision weapons and stealth technology but also such icons of modern society as the Internet, automated voice recognition and language translation, and Global Positioning System receivers small enough to embed in myriad consumer devices. Our work today aims to have similarly exceptional impact in the future.

I have noted that DARPA explicitly reaches for transformational change instead of incremental advances. Importantly, however, it does not perform its engineering alchemy in isolation. It works within an innovation ecosystem that includes academic, corporate and governmental partners, with a constant focus on the Nation's military Services, which work with DARPA to create new strategic opportunities and novel tactical options. For decades, this vibrant, interlocking ecosystem of diverse collaborators has proven to be a nurturing environment for the intense creativity that DARPA is designed to cultivate.

OPERATING IN A GLOBAL CONTEXT

I have emphasized that DARPA's mission and philosophy have held steady for decades, but it is equally important to note that the world around DARPA 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 some deeply disturbing technical, economic and geopolitical shifts that pose potential threats to U.S. preeminence and stability. These dueling trends of unprecedented opportunity and simmering menace—and how they can be expected to affect U.S. national security needs a decade and more from now—deeply inform DARPA's most recent determination of its strategic priorities for the next several years.

To understand those priorities in context, it is important to start from the undeniable premise that America is in a very strong position today and is endowed with enormous advantages as it enters the last decade before its 250th birthday. But DARPA's mission is to look beyond the reality of today and to focus on futures we anticipate may emerge. And a number of current trends provide sobering reminders that continued U.S. global pre-eminence cannot be taken for granted.

On the technology front, for example, the Nation faces the growing challenge of maintaining domestic superiority even as sophisticated components and systems once available almost exclusively to U.S. forces become increasingly available on the global market. This reality is largely the result of otherwise beneficial economic forces that have made once-proprietary products less expensive and more accessible. But it points to the need for approaches other than technological exclusivity to maintain U.S. economic strength and military superiority.

Challenges relevant to DARPA's work also loom on the geopolitical front—including peer adversaries and other nation states that pose conventional- and nuclear-weapon threats as well as terrorist groups and other non-nation-state actors. These latter groups pose unique risks in part because they operate outside

the bounds of international conventions and so are less responsive to conventional approaches to deterrence.

Finally, DARPA and the Nation face the accelerating and overarching challenge of increasing pace—the fact that in virtually every security-relevant domain, change is coming quicker than ever, as is the need to be nimble and adaptive. Pace today matters on every scale, from the micro- and nanosecond time scales at which our information and radio frequency systems operate to the decades it currently takes to design, develop and deploy new complex weapons systems. And of course pace is central to success on the battlefield, where communications must be instant and accurate, intelligence must be current to the moment, and weapons must close on target before the adversary moves.

These are kinds of challenges and future perspectives that inform DARPA's priorities today.

DARPA'S INVESTMENT PORTFOLIO

DARPA's strategic priorities can be grouped within four areas, each one focused on developing and ensuring a family of key capabilities. The summaries below outline the focus areas within each of those four areas; further details about each are available in "Breakthrough Technologies for National Security" released today and available on DARPA's website, www.darpa.mil.

Rethink Complex Military Systems

Across many warfighting and security domains, U.S. capabilities are powerful today but neither sufficiently robust nor adequately scalable for the future the Nation faces. For example, modern weapons today are spectacularly complex, and the multipurpose platforms on which they reside only add to the enormity of this complexity. To be sure, these systems are formidable and have been overwhelmingly successful to date. But there is growing evidence that, under current practices, the benefits of these remarkably complex architectures are being undermined by inherent drawbacks. Today, many high-end weapons platforms are so complex they take decades to produce and years to upgrade. In a world in which pace is inexorably increasing, and in which other economic and manufacturing sectors have recognized the benefits of systems modularity, rapid-fire iterative

improvements and faster hardware- and software-system upgrades, the military's current approach to harnessing complexity is outdated and inadequate, and risks leaving the Nation vulnerable to adversaries developing more nimble means of adopting the latest technologies.

To initiate new trajectories for military capabilities in this shifting landscape, DARPA is addressing the following challenges:

- Assuring dominance of the electromagnetic spectrum
- Improving position, navigation and timing (PNT) without GPS
- Maintaining air superiority in contested environments
- Leading the world in advanced hypersonics
- Asserting a robust capability in space
- Enhancing maritime agility
- Exerting control on the ground
- Augmenting defense against terrorism

Master the Information Explosion

Global digital data is in the midst of a seemingly boundless growth spurt. Every minute of every day, more than 300 hours of video is uploaded to YouTube and hundreds of new Web sites are launched. Nearly $5x10^{22}$ bytes of digital data are predicted to be generated by 2020—about ten times the current volume. And of the approximately $5x10^{21}$ bytes created as of 2014, an estimated 90 percent was generated in the previous two years alone. Adding to this widely available information is the deluge of bits generated by military and intelligence sensors.

This accelerating glut of information—and the Nation's increasing reliance on information systems in every sector of society—present a challenge and an opportunity. The opportunity is to derive from this massive trove the myriad associations and causalities that, once unveiled, can provide insights into everything from the predicted arrival of a new strain of influenza to the plans for a terror attack halfway around the globe. The challenge—virtually the same as the opportunity—is how to separate signal from noise to derive these insights, and how to know when to trust the information in hand.

DARPA is developing novel approaches to deriving insights from massive datasets, with the goal of enabling the operational user of information with powerful big data tools. The Agency is also developing technologies to ensure that the data and systems with which critical decisions are made are trustworthy. That includes, for example, automated cyber defense capabilities and methods to create fundamentally more secure systems.

Harness Biology as Technology

The recent maturation of genetic technologies and bioinformatics—in conjunction with recent breakthroughs in neuroscience, immunology and related biomedical fields—have begun to erase the longstanding gap between the life sciences, engineering and computing disciplines. This synthesis is catalyzing the creation of a new interdisciplinary domain rich with potential breakthroughs in areas as diverse as mental health and materials science.

Recognizing that this largely unexplored opportunity space is ripe for early, game-changing attention, DARPA in 2014 created its Biological Technologies Office, which has enabled a new level of momentum for DARPA's portfolio of innovative, bio-based programs. DARPA's work in this area includes programs to accelerate progress in synthetic biology, outpace the spread of infectious diseases and master new neurotechnologies.

Expand the Technological Frontier

From its earliest days, DARPA's core work has involved overcoming seemingly insurmountable physics and engineering barriers and, once showing those daunting problems to be tractable after all, applying new capabilities made possible by these breakthroughs directly to national security needs. That tradition holds true today.

Maintaining momentum in this core component of the agency, DARPA is working to achieve new capabilities by applying deep mathematics; inventing new chemistries, processes and materials; and harnessing quantum physics.

MAKING A DIFFERENCE—FROM CONCEPT TO REALITY

The four broad areas above describe DARPA's portfolio of programs today. Across that portfolio, DARPA's performers are achieving significant technical progress—the first important step in the journey to achieving our mission. In my testimony today, I would like to highlight what comes next from DARPA's programs: the transition of technical results into use.

DARPA's mission is to reveal new possibilities and enable groundbreaking capabilities by developing and demonstrating breakthrough technologies, but true success happens only when these technologies make significant, transformative improvements in the Nation's security. That's why, even before a program launches, DARPA starts developing strategies for transitioning anticipated results into the hands of those who can put them to work.

Transitions are rarely simple and can follow different paths. In fact, the successful transition of a technology to a military, commercial or other entity is, in itself, still but an intermediary step to the final goal of revolutionary impact, which can be a years-long process. DARPA pursues and catalyzes a wide range of transition pathways, each selected to maximize the ultimate impact of a given technology.

In some cases, a DARPA program that demonstrates a military systems capability will become a program of record in one or more of the Services. In other cases, new DARPA-enabled technologies will transition first to the civilian sector, where commercial forces and private capital may drive further advances and cost efficiencies that can facilitate incorporation into military systems. In still other cases, DARPA's role ends after proving at a fundamental level the potential for a new capability, after which a military or civilian organization will typically pick it up for further research and development.

Because DARPA focuses explicitly on game-changing, non-incremental goals, some DARPA efforts do not transition upon their conclusion—either because the technology itself failed or because the resulting capability promises to be so disruptive that, in the short term at least, it cannot be integrated into existing systems or strategies. In those cases, years may pass before a DARPA-supported advance gets the opportunity to make its mark, after related technologies mature or other contexts evolve in ways that make the advance more practicable.

In recognition of the essential importance of technology transition as well as the complexity and challenges inherent in transitions, DARPA has a support office—the Adaptive Execution Office—dedicated to transition alone. Staffed by a team of individuals with deep experience in the military Services and working in close collaboration with Service liaisons, the office is committed to finding and facilitating the most effective path from the research laboratory to operational impact for DARPA-supported technologies.

Notwithstanding the many inherent challenges to successful transition, technologies that had their genesis in DARPA programs can be found inside countless military capabilities today—and the Agency continues to make progress toward transition from its current and recent programs. Examples include:

Riding the Gallium Nitride Wave

For years, DARPA and its Service partners pursued the technically daunting task of developing high-power-density, wide-band-gap semiconductor components in the recognition that, whatever the end-state task, U.S. forces would need electronics that could operate and engage at increasing range. The result was a series of fundamental advances involving gallium-nitride-enabled arrays, which now are providing significant benefits in a wide range of applications in the national security domain. Today, three major systems under development are enabled by DARPA's advances in radio frequency (RF) component technology: Next Generation Jammer, designed to give the Navy the ability to jam adversary radars to protect U.S. assets; Air and Missile Defense Radar, which is designed to search for and track ballistic missiles and provide terminal illumination of targets; and Space Fence, to boost space domain awareness by providing vastly improved detection of small objects in orbit.

Creating Deep-Ocean "Satellites"

DARPA's Distributed Agile Submarine Hunting (DASH) program is creating fixed and mobile underwater observing systems that look up from the ocean floor. Just as satellites provide a wide-area view of the ground from space, these systems can see submarine threats passing overhead across vast volumes of ocean. This deep-ocean system has as a goal the ability to track a submarine until other platforms can arrive to track, trail or prosecute the threat. DARPA is working with Navy

operational commanders in the Pacific and the Atlantic to conduct at-sea prototype testing that will integrate these new capabilities with existing undersea surveillance operations—testing that will underpin Navy consideration of a potential program of record for undersea surveillance.

Delivering Long-Range Anti-Ship Capabilities

DARPA jumpstarted the development of the Long Range Anti-Ship Missile (LRASM), a precision-guided standoff missile that is on track to reduce dependence on intelligence, surveillance and reconnaissance (ISR) platforms while extending range significantly. After successful flight tests in August and December 2013, the Navy stepped up to work in close partnership with DARPA. With yet another successful test in February 2015, this time led by the Navy, the joint effort is speeding deployment of this system to deliver its unprecedented capabilities for the warfighter.

Gathering and Sharing Critical Information

Extending DARPA's longstanding commitment to provide the Services with the best available technologies for ISR, DARPA has signed a technology transfer agreement with the Joint Special Operations Command (JSOC) allowing the Command to receive and operate the Autonomous Real-time Ground Ubiquitous Surveillance-Imaging System (ARGUS-IS). This very-wide-area, high-resolution motion video sensor is enabled by advanced on-board processing and an integrated ground station that allows interactive designation and tracking of multiple targets simultaneously. This technology will provide warfighters unprecedented ability to see, understand and engage hostile networks and high-value targets. The JSOC is integrating this package onto a manned platform for further development to enable near-term combat deployment.

Exploiting Photo and Video Images

Burgeoning volumes of images collected in support of surveillance and reconnaissance efforts—such as photo and video albums stored on laptop computers confiscated from insurgents during DoD operations—are growing at such a rate that unassisted analysis cannot keep up with demand for interpretation. DARPA has developed and transitioned to relevant agencies several technologies

that are enhancing analysts' productivity, including technology that searches imagery and video archives for persons, objects, events and activities of interest; novel interfaces to support live video exploitation; and the capability to track all movers in a dynamic field of view.

Digitizing Close Air Support

When ground forces have identified the location of an adversary out of their reach, or are pinned down and in need of support from the air, they should not be dependent on paper maps and voice communications to convey essential information to pilots. Yet that has been the case, until recently. DARPA's Persistent Close Air Support (PCAS) system digitizes and greatly simplifies the mission-critical capability of air support. Today, DARPA is transitioning PCAS' air and ground technologies to Army Special Operations Command (USASOC), giving ground elements the capability to request air-delivered munitions from manned or unmanned platforms with unmatched accuracy and shared awareness. Specifically, USASOC has committed to integrate and deploy PCAS technology with its fleet of MQ-1C Gray Eagle unmanned platforms and related networking systems.

Searching the Deep Web

Today's web searches use a centralized, one-size-fits-all approach that uses the same set of tools for all queries. While that model has been successful commercially, it is inadequate for a number of national-security-relevant applications because it neither recognizes nor aggregates shared content across pages and misses information in the deep web—the web domains not indexed by standard commercial search engines. DARPA's Memex program has developed software that advances online search capabilities far beyond the current state of the art and is already revolutionizing the discovery, organization and presentation of domain-specific, deep-web content. DARPA's initial focus has been on fighting human trafficking, an illicit enterprise with implications for and connections to many types of military, law enforcement and intelligence investigations. With a number of initial successes in that domain—including arrests and a recent conviction—the program is now being expanded for use by DoD in the fight against the Islamic State of Iraq and the Levant, or ISIL.

Revolutionizing Prosthetics

Recognizing the particular debt our Nation owes to those seriously wounded in battle, DARPA several years ago launched a concerted effort to improve upper-limb prosthetic technology, which, reflecting the medical and engineering challenges posed by the complexities of the human arm and hand, had trailed far behind lower-limb technologies. In 2014, capping an intensive effort by DARPA's Revolutionizing Prosthetics program, the U.S. Food and Drug Administration gave marketing approval for a modular prosthetic arm and hand that provides unprecedented user dexterity. Users can once again perform everyday activities such as feeding themselves, shaking hands and offering a child a pat on the back or a hug.

KEEPING DARPA VIGOROUS

DARPA's leadership takes seriously its responsibility to maintain and encourage the agency's culture of innovation and its ability to execute rapidly and effectively.

At the center of DARPA's success is an abiding commitment to identify, recruit and support excellent program managers—extraordinary individuals who are at the top of their fields and who are hungry for the opportunity to push the limits of their disciplines during their limited terms at DARPA. I am most grateful for the critical support this Subcommittee provided last year for expanding DARPA's ability to use its 1101 hiring authority. That authority has proven invaluable to our ability to attract some of the finest scientists, engineers and mathematicians to the important work of public service and national security.

DARPA's technical staff is also supported by experts in security, legal and contracting issues, finance, human resources and communications. These are the people who make it possible for program managers to achieve big things during their relatively short tenures.

Having worked in several agencies in the public sector and several companies in the private sector, I am acutely aware that a humming, effective enterprise is never achieved by accident. Congress has played a vital role in DARPA's success over many years, providing through legislation the tools to recruit stellar people, work in new ways with companies outside the traditional defense contractor community,

and build communities around prize challenges—experimenting, learning and adapting all the while. Thank you for this important support.

DARPA'S BUDGET

The President's FY 2016 budget request for DARPA is $2.973 billion. This reflects an increase of $57 million compared to the $2.916 billion appropriated for FY 2015. To put these numbers in context, from FY 2009 to FY 2013 DARPA's budget declined steadily through a series of reductions, including the 8 percent across-the-board sequestration cut in FY 2013. The total reduction to DARPA's budget from FY 2009 to FY 2013 was 20 percent in real terms.

With modest increases in FY 2014 and 2015, the budget has now recovered slightly, gaining back about 7 of those 20 percentage points in real terms. I thank this Subcommittee, and Congress more broadly, for your support over the past two years to stabilize the budget. And I ask for your support of the President's budget request for FY 2016 so we can continue to deliver on our vital mission.

I will also note that the implementation of sequestration under the Budget Control Act will have real and negative impact on our work. We do not have to speculate about sequestration effects; unfortunately, we know from the experience of FY 2013 what will happen. Cuts will mean that some important new programs will be delayed. Some existing programs will end prematurely, before achieving their critical milestones. Demonstrations will be delayed, and because they typically involve our Service partners and test facilities, these projects will ultimately cost more to complete after multiple interlinked schedules are rebuilt. As in prior years, no single cut is a death blow. Rather, the cumulative effect is an erosion of our ability to execute our mission and an erosion of the confidence that the wider technology community has in government.

CONCLUSION

I have spoken today about many challenges facing our Nation, and we in DARPA take these threats very seriously, as do all our colleagues throughout the DoD and across government. But one of the wonderful things about working in a place like DARPA is that our day-to-day work is always about solutions—about creative ways to neutralize risk and rise above danger. In that sense, DARPA is a very

optimistic and even joyous place to work. So it is not just our responsibility but also our privilege and passion at DARPA to strive every day to cultivate and harness emerging technologies in the cause of U.S. national security.

I thank you for your trust, and I will be pleased to respond to your questions.