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Statement by Dr. Arati Prabhakar

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Defense Advanced Research Projects Agency

Submitted to the

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Chairman Hagan, Ranking Member Fischer, 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 (DARPA).

Three major factors drew me back to DARPA last summer after 19 years in other roles. The first was DARPA's disproportionately large impact on our current national security and technology capabilities. The second was the challenge of driving the technologies that will be cornerstones of our national security in the complex world we face in the years ahead. And the third was the privilege of leading this unique Agency, filled with people who come to work each day in vigorous pursuit of our important mission.

Today I'd like to tell you about each of these aspects of DARPA. I will include a discussion of our objectives and strategies, specific areas of investment, and our budget in the President's Fiscal Year (FY) 2014 request.

The starting point for our discussion today is the future security of the United States. We all understand the world is complex and changing in ways that will pose new threats to our national security. We all understand that resources will be constrained as we reshape defense budgets. But U.S. security capabilities must remain second to none despite these uncertainties and pressures. New technology has consistently created better options for our leadership - and better security outcomes for our Nation. Today, it is vitally important to continue to focus on the technology investments that will lead to a new generation of national security capabilities for our future. This commitment is reflected in the President's budget request for DARPA in FY 2014.

Before turning to DARPA itself, I'd like to set the context for our Agency in our Nation's research and development (R&D) efforts. DARPA is a projects agency, and we accomplish our objectives through deep engagement with companies, universities, Department of Defense (DoD) and other labs. Our success hinges on having a healthy U.S. R&D ecosystem. Within DoD Science and Technology (S&T) efforts, our role is to invest in high-payoff opportunities that often require taking significant risk. We work closely with our colleagues in the Service S&T organizations, sometimes building on their early research and drawing on their technical expertise, and often relying on them to help us transition successful results to military use.

DARPA's Impact

DARPA's recent transitions won recognition last fall when then-Secretary of Defense Leon Panetta gave the Agency the Joint Meritorious Unit Award, recognizing numerous contributions for the war effort. The award singles out the "creative intellect and keen expertise" that delivered "innovative cutting-edge technology to save lives and improve mission success amidst constantly evolving threats." Responding to urgent needs from troops on the ground, DARPA created and fielded a wide range of highly effective tools. These included a system that delivered three-dimensional views of the battlespace to operational and intelligence users, a radar pod to track threat vehicles and dismounted personnel, a radio system capable of interoperable communications and large data transmissions, a detection system that assesses blast exposure and medical risk to personnel, and a framework for the analysis of large amounts of data that provided unique and valuable insights to help answer key strategic and operational questions.

DARPA program managers, staff, and our partners were all excited to receive this recognition for what we work towards every day: creating new technological solutions and transitioning them into practice.

Because DARPA's enduring mission is to change the game in our favor when it comes to U.S. security capabilities in a rapidly shifting global context—and to do that by creating surprise for our adversaries and preventing surprises to our own forces—our warfighters long have depended upon many military systems that originated in earlier DARPA work. Aircraft with stealth capabilities, unmanned aerial vehicles (UAVs), night vision for our warfighters who now essentially "own the night" largely because of infrared imaging, the seemingly omnipresent global positioning satellite (GPS) capabilities for navigation and precision guided weapons, an arsenal of advanced communications and computing capabilities, and advanced intelligence, surveillance, and reconnaissance (ISR) are all well known and publicized examples. The list goes on and on, and it includes revolutionary changes in how the world thinks about important areas of science and technology, including information technology and materials science. The list also includes some elegant and important advances that do not get public attention by the nature of their applications. Simply put, our military has taken DARPA-initiated advances and used them to change warfighting dramatically. This is how we keep the scales tipped in our direction.

Looking to the Future: Technologies for the Next Generation of National Security

Today, as the Nation moves to the end of the active engagements of the last many years, it is time to look ahead and ask the fundamental questions for DARPA's mission. How do we create highly effective options for our future leaders in the face of the national security challenges of the coming decades? How do we dramatically change warfighting, once again changing the game in our favor faster than others can respond? How will we deter and defeat the many kinds of threats that many kinds of actors around the globe will attempt?

DARPA's new framework, captured in a document transmitted to this committee recently along with the President's FY 2014 budget request, describes how we think about this all-important question. "Driving Technological Surprise: DARPA's Mission in a Changing World" places great importance on the rapidly changing context in which our military leaders, warfighters, and DARPA now are operating. It explains how we anticipate, explore, and achieve the concepts and technology on which the Nation's future deterrent and defense capabilities depend. I will draw in part on that framework in my testimony.

The United States has seen great change that has affected our civilian and defense capabilities, positioning, and plans that challenges us every day. There is nothing new about needing to deal with changes in our adversary's capabilities. That is a big part of the history of armed conflict and its prevention or successful execution.

Today's Environment and DARPA's Strategic Objectives

But today's environment is different from the past. First, the Nation faces complex security challenges. Some are very real and some are potential in nature—but all demand viable options

for our Nation's leadership. We are finishing a counterinsurgency operation and building local security capabilities in Afghanistan. An array of diplomatic, intelligence, and possible military measures must be ready if needed to address nuclear uncertainties posed by Iran and North Korea. Our government and private networks deal with the growing onslaught of more capable and frequent cyber-attacks from many sources on an ongoing basis. Potential adversaries are deploying sophisticated capabilities to contest our ability to project military power. And a look into the future only adds uncertainty. The proliferation of nuclear, chemical, and biological weapons of mass destruction or terror; the flare-up of tensions among nations in hot spots around the world; growing pressures in the urbanizing developing world; and the globalization of technology and new R&D are all trends we can see.

This shifting, unpredictable national security environment demands a wide range of capabilities for the future and the agility to both anticipate and respond to whatever comes.

I want to underscore a point: the technology base upon which our military systems are critically reliant is highly globalized. This introduces potential vulnerability in both the assurance of supplies and the security of the supply chain. At the same time, other players have the same access to this supply of highly capable components, and many have used them to quickly develop weapons systems with highly advanced capabilities. This pattern of globalization, wide availability, and growing vulnerability pervades most of the core technologies upon which our defense systems rely. Our challenge is to create an edge for U.S. national security purposes in this environment.

The second significant factor driving our objectives going forward is the possibility of a change in public investment for national security. Because DARPA's prime directive is to prevent strategic surprise and enable our superiority, we must consider what will be required to meet the Nation's security needs even in these circumstances.

The uncertainties we face—threat uncertainties and fiscal uncertainties—do not change the fact that the Nation relies on DoD to deter war and protect the security of our country, and DARPA's role here is vital.

DARPA's Approach

Our first two primary objectives are:

1) Demonstrate breakthrough capabilities for national security, and
2) Catalyze a differentiated and highly capable U.S. technology base – critical to achieving the first objective.

Several approaches shape our thinking as we attack the need for breakthrough capabilities for national security:

1) *Game-changing new systems technologies*. Today's warfighters rely on systems from aircraft to navigation to communications that trace their history to earlier DARPA work. Looking ahead, some of these may become vulnerabilities as sophisticated adversaries also understand how crucial these systems are to warfighting. So, DARPA seeks to create the next generation of new capabilities that once again changes the game in our favor faster than others can respond.

2) *Layered, multi-technology war fighting concepts.* Modern warfighting is too complex for a single new capability to deliver sustained superiority across a variety of scenarios. But combining multiple technology advances by layering and integrating them can lead to a revolution in capabilities. Looking ahead, we can imagine coordinated local position, navigation, and timing (PNT); adaptive electronic warfare; manned and unmanned systems working in harmony; tactical cyber effects; and advanced ISR – all woven together in ways that create decisive surprise in tomorrow's conflicts.
3) *Adaptable systems and solutions. While military technology and weapon systems have continued to evolve and mature over time,* our military engagements of the last 20 years have been fought with systems developed largely for Cold War scenarios. Our warfighters have had to adapt for the realities on the ground. Today when we consider future engagements, we can more readily imagine a host of diverse environments and adversaries. In an uncertain world, adaptability is critical. We won't always know what we will need for tomorrow's battle, and our adversaries will change their tactics and technologies over time. So systems that can be readily upgraded and adapted in real time to changing surroundings and conditions will play an important role.
4) *Innovation to invert the cost equation.* Today we seek to use innovation to radically invert the cost dynamic. How can we impose more cost on our adversaries and less on ourselves, thereby increasing our deterrent? Can innovative systems architectures, autonomy, adaptability, and new processes offer new possibilities? These approaches may allow us to reinvent development, production, logistics, operations, and maintenance in ways that radically change the cost equation.

Two themes shape our efforts to <u>catalyze a differentiated and highly capable U.S. technology base</u>:

1) *Exploiting and transcending commercially available technologies.* We seek to be the best user of globally available technologies – to use them with greater creativity to solve problems more quickly, efficiently, and flexibly. This means novel systems architectures as well as integrating specialized niche technologies with commercially available components to create unique solutions.
2) *Catalyzing new national technology capabilities*. Entirely new technologies open the door to national security applications that can't even be imagined beforehand. We recognize that many of these technologies will also globalize. But the time advantage to the United States, if we pursue them first, can be substantial and make all the difference. We approach this challenge in several ways:

- Exploring new technology possibilities from fertile basic and interdisciplinary research. Universities, government labs, and private R&D organizations are bubbling with intriguing new research across many disciplines and new interdisciplinary fields. Some hold the seeds for the next technology revolution. We actively search for these promising activities and explore where these new insights might lead.
- Building foundational technology infrastructure and communities. DARPA has a long history of building technology infrastructure that becomes the foundation for wide arrays of applications. Today, we are using the same approach in new fields. Our programs create the tools, techniques, and communities that scale well beyond the period of our investment.

- Demonstrating the new capabilities that technology enables. Changing minds about what's possible rarely happens just through writing papers and reports. Projects that build prototypes show how technical breakthroughs enable new capabilities.

The President's FY 2014 Budget

The President's FY 2014 budget proposal for DARPA is $2.865 billion. This is on par with the $2.817 billion originally budgeted for DARPA in FY 2013, but has now been reduced to $2.785 billion following congressional action. The FY 2013 budget has been further reduced by approximately $223M as a consequence of sequestration.

Before discussing our FY 2014 plan, let me explain our FY 2013 status under sequestration. As I'm sure you know, sequestration is having a significant effect on our work during this fiscal year. At DARPA, we have prioritized within each Program Element to execute cuts as intelligently as possible, but with cuts of this size there are real consequences. We are projecting up to 14 days of furloughs for our civilian government employees, and we are delaying or eliminating programs as a result of the 8% cut in each Program Element. While the planned furlough days are of course a financial concern for our employees, our people are also deeply frustrated they will not be allowed to do their jobs on these days. This unfortunate message makes it that much harder to recruit and retain the stellar individuals we need to accomplish our mission. Programs across the Agency are affected by the sequestration cuts. Two examples include Plan X and the Microtechnology for Positioning, Navigation and Timing (microPNT) program. Plan X, which aims to integrate cyberwarfare and kinetic fighting, is being cut by 43% in FY 2013, delaying its start by five months. The microPNT program, which is developing the capability for precise, self-contained PNT in severe environments, will see a 9% cut, delaying testing with the Air Force and driving additional schedule extensions.

Looking forward, the proposed FY 2014 budget would provide us with resources to address or—in some cases, begin to address—our essential programs. I'd like to highlight a number of areas that range from particular military systems to broader, enabling technologies.

Cyber foundations for a scalable new trajectory: DARPA's cyber programs tackle two aspects of this broad challenge that are redefining the rules of warfighting. One is to create the capabilities that will allow us to move beyond today's "detect and patch" approach to a more fundamental defense of our cyber systems. We aim to provide cybersecurity and survivability solutions that enable DoD information systems to operate correctly and continuously even when attacked. The second aspect focuses on cyber effects in tactical warfighting scenarios. We can readily imagine a future in which cyber warfare is fully integrated with kinetic warfare. DARPA's cyber offense efforts aim to create the tools that bridge these domains, for example, by providing simulations of cyber effects, battle-damage assessments, and layers of authority and control.

Cost-effective space systems in a newly contested environment: Unsustainable cost growth has materially affected the development of future U.S. capabilities in the all-important environment of space upon which DoD, the intelligence community, and commercial sectors rely. DARPA is tackling these challenges by focusing on affordable routine access, agile systems development at lower cost, survivable and resilient systems, disaggregated and simplified systems, and a holistic

approach to space situational awareness. For example, one DARPA effort is striving to drive the cost of space access down to $1 million per launch and increase the tempo to single-day turnarounds. Creatively—and ambitiously—another program is exploring cooperatively harvesting and reusing valuable retired satellite components to build an entire new space system in geosynchronous orbit. If successful, this would be a major contribution to achieving the goal of reducing today's overall satellite system cost by 90 percent.

Air Dominance: Our forces have had the upper hand in air combat for many years now. But as others use globally available technologies to build new and sophisticated systems, resting on our laurels would be a dangerous course. With the support and endorsement of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Frank Kendall, DARPA has teamed with the Air Force and Navy to study the challenges of air dominance for the next generation. The working group is investigating how we can build on our current capabilities with new technologies and concepts, inverting the cost equation to force future adversaries to spend much more to counter than we do to field and employ. The team is taking a broad, integrated approach, looking at electronic warfare and sensing across the electromagnetic spectrum, communications and networking, space, cyber, weapons, and platforms. We anticipate this study effort will lead to new initiatives, with the ultimate goal of ensuring the United States continues its air superiority in the 2020-2050 timeframe.

Countering Weapons of Mass Destruction (WMD): We are pursuing efforts to increase efficacy and accelerate the timeline for bioweapon threat response, including novel techniques that will enable the human body to directly manufacture its own vaccines, bypassing traditional vaccine manufacturing processes that can take months. In addition, we are studying current challenges in countering chemical and nuclear WMD threats. For example, we are investigating a defense-in-depth approach, combining novel detection methods and big data intelligence analytics to achieve a more robust, layered solution. We are also looking into new medical countermeasures for increasing the survivability of victims of acute radiation poisoning.

Position, navigation, and timing (PNT) capabilities beyond our critical reliance on GPS: DARPA's recent programs in PNT originally sought to take GPS-like capability to the places where GPS currently does not operate, such as indoors, underwater or underground. As concerns surfaced about our critical dependence on GPS, those initial investments are starting to create GPS alternatives, as well as new enablers for future military systems. We have developed micro-PNT technologies and are transitioning them to use. We are developing new inertial measurement units and clocks that use atom interferometry for very long duration missions, as well as techniques that use available signals – from television, radio, cell towers, or even lightning – to augment or replace the location information that GPS currently provides. And in keeping with the drive for adaptability, our new approach to full navigation systems integration could provide rapidly configurable solutions for the many types of platforms that require advanced PNT.

Electronic warfare (EW) to counter and move beyond adversaries' advancing capabilities: We face important challenges as we seek to protect our assets and deploy EW capabilities. Not the least of these is the reality that 90 percent of the electronics needed in an EW system can now be bought commercially. DARPA is attacking these challenges. For instance, DARPA is developing

a new architecture for the radar antenna arrays with which ships and planes transmit and receive radar pulses. The goal is to make them in modular fashion, obviating the need for unique designs for each new application and permitting new and multiple modes of use. This has the potential to drive future radar costs down significantly, while simultaneously improving performance. Another challenge, and there are many, is that the system performance of many radios and radar units is constrained by the performance limits of electronic components inside those units. DARPA aims to drive technology capabilities well beyond commercial specifications and to extend important electronic components to performance regimes unreachable by commercial technology.

Engineering biology tools to engineer microorganisms for materials with new properties: Engineering biology is emerging as a new field as researchers across multi-disciplinary labs have started to design and construct genetic pathways, networks, and systems to harness the powerful synthetic and functional capabilities of biology. We can see the potential to develop new and transformative materials, sensing capabilities, and therapeutics. But synthetic biology today is still a multi-year, ad hoc, trial-and-error process constrained to a limited number of simple products. DARPA's investments in the Living Foundries program are developing the tools and technologies to create a new engineering practice, speeding the biological design-build-test cycle and the rate at which we realize novel products and capabilities. Drawing upon and building on the research base, these efforts will begin to create the foundational infrastructure for engineering biology. Some of the first outputs may include new materials and medicines such as antifungals, lubricants, and energetic materials. Beyond these are a new generation of products with properties we can only imagine today.

Big data capabilities to draw insight from multiple data sources**:** Exponential improvements in computing power, network bandwidth and storage density combined with ever more pervasive sensing and measurement technologies give us enhanced tools for drawing information and insights from massive, heterogeneous data sets. In the national security realm, harnessing big data offers special challenges. National security often involves actors with a vested interest in remaining unobserved. Data sets may be corrupted, incomplete, or disaggregated to the point that sophisticated technologies are required for cleanup. Data sets may be multimodal, real time-streamed, or on a scale for which storage isn't feasible and requires new processing approaches. Moreover, in many national security applications, inferences must be drawn, relationships deduced, or anomalies detected working solely from data sets that are weak proxies for the underlying quantities of interest. The varied ways in which data are gathered pose challenges in fusion. And while the cost of investigating false alarms is often high, the consequences of a missed detection are even greater. These challenges are being addressed across DARPA's big data portfolio. The effort begins at the basic science level and also addresses fundamental computational issues such as novel algorithm design, natural language processing, and architectures for efficient processing of streamed data. At the other end, DARPA is working closely with national security agencies on operational data to ensure continuous transition of tools as programs progress.

Brain function research: DARPA plans to build on its past and ongoing research to help advance a new understanding of brain function to treat injury, create new brain-machine interfaces, and inspire new algorithms and hardware. Earlier this month the President announced an initiative to

revolutionize our understanding of the human brain. DARPA's brain function research will play an important role in the initiative, with the goal of understanding the dynamic functions of the brain and demonstrating breakthrough applications based on these insights. DARPA aims to develop a new set of tools to capture and process dynamic neural and synaptic activities, and explore ways to dramatically improve the way we diagnose and treat warfighters who are suffering from post-traumatic stress, brain injury and memory loss.

I want to note that we pursue technologies like these because of their promise, but we understand that in this pursuit, we might be working in areas that raise ethical, legal, security, or policy questions. Here, our job is twofold. We must be fearless about exploring new technologies and their capabilities; this is our core function and our Nation is best served if we push these frontiers ahead of other countries. At the same time, we must raise the broader societal questions and engage those who can address them. We ensure our work adheres to laws and regulations. In new and uncharted territory, we reach out to a variety of experts and stakeholders with different points of view. In many instances, technology solutions can be part of the answer to new concerns. But we recognize that at their heart, these are societal questions that require a broader community be engaged as we explore the technological frontier.

A wide array of other DARPA programs also reflects our investment approaches for breakthrough systems and technologies. They include programs in maritime and undersea systems, hypersonics, communications, ISR, robotic systems, innovative manufacturing technologies, adaptable sensor systems, and unconventional computing platforms. More broadly, we also invest in early-stage research efforts across physics, materials science, mathematics, and interdisciplinary fields with the potential for future technological applications. The President's FY 2014 budget includes funding for this critical work.

Keeping DARPA Robust and Vibrant

To accomplish our vital mission, it is essential that we keep DARPA robust and vibrant. So our third objective is to *ensure a highly functional environment and the foundation for a strong culture.*

With just 210 government employees we carry out 250 programs across five technology offices. How is this possible? In addition to having a cadre of very capable support functions and contractors, we rely heavily on active engagement with the technical community and users, as I emphasized earlier. Our success hinges on our ability to work with tiny companies to universities and major contractors to labs of every stripe. It hinges on our relationships with and the work of the users of our results across DoD.

DARPA's program managers are the core of our organization, and they are stellar. Each is a leader who brings to DARPA an adventurous spirit and a deep conviction that his or her technology vision will change the world. They come to DARPA because this is the place that gives them the opportunity to take breakthrough technologies to fruition. Our program managers generally serve 3 to 5-year terms, leading to a constant flow of new people and fresh views.

That is why our hiring authorities are so important to us. DARPA uses a dynamic mix of hiring and retention authorities enabling the Agency to continue to hire and retain the nation's most qualified technical experts from industry, academia, and the private sector with speed and flexibility not allowed by standard civil services processes. Moving forward, maintaining and fostering a robust and vibrant DARPA hinges on our continued ability to recruit and retain the people who will meet the challenges of an ever-changing threat environment.

I would like to thank the Subcommittee for its continued support of DARPA's hiring authorities. It has been enormously helpful to us, and we simply could not attain our high caliber staff without it.

From Basic Science to Military Advantage: How a Clock Could Make a Difference

Let me conclude with a specific example of how we do our work – one of the numerous individual efforts underway in our portfolio today.

Earlier in my testimony I cited our important work on position, navigation, and timing systems as we strive to develop capabilities beyond what GPS systems offer us today. Position and time is oxygen for our warfighters, but GPS signals can be degraded or denied by adversaries who aim to jam or spoof our signals.

One of our novel PNT approaches captures how DARPA's ability to think outside the box, and our constant search for new ideas and surprises, can lead to the hard-nosed practical solutions we must have for technological superiority in national security.

Frequency and timing devices are essential components in modern military systems. The stability and accuracy of these devices affect the performance of communication, navigation, surveillance, and missile guidance systems. Atomic clocks are at the core of many of these systems, either directly or by synchronization with a master clock.

DARPA is now building on exquisite Nobel Prize-winning science conducted in the mid-1980s that enlisted lasers to cool and trap atoms, and work from the late 1990s to precisely read out these atomic states. Although it was far from apparent then, these fundamental physics discoveries, and the basic science work that followed over the next two decades, now holds the promise of allowing DoD to develop a dramatically improved atomic clock device.

But the best atomic clocks operate only in lab environments – large rooms with scientists to tend their complicated laser systems. That severely limits practical applications. Still, DARPA recognized the promise that timekeeping-related advances held for military uses. So we aimed to develop simpler clock architectures based on the initial Nobel Prize research and related work that would still meet our needs.

That is much, much easier said than done, of course. After some very hard work by a very talented team, we are now developing a shoebox-sized optical atomic clock that offers dramatic reductions in size, weight and power requirements. It aims for unheard of accuracies for a device of its size (within one billionth of a second over the course of a year). The payoffs will be huge if

we are successful: secure data routing, communication systems that are insensitive to jamming, high-resolution coherent radar, and more reliable and robust global positioning. An accurate local clock would be one critical enabler of continued operation of military systems in the absence of GPS.

If successful, in combination with other technologies we are working on, this new clock developed under the QuASAR program will lead to a new set of PNT technologies – a pillar of the next generation capabilities that DARPA is building. In short, this device, along with the many other technologies we are driving, can transform war fighting for our future needs. That would be a true game-changer – and that, after all, is what DARPA is all about: changing the game in our Nation's favor.

Thank you for your support of DARPA, and for allowing me to testify before you today. I look forward to your questions.