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Subcommittee on Terrorism, Unconventional Threats and Capabilities,
House Armed Services Committee, U.S. House of Representatives

Statement by Dr. Regina E. Dugan

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Submitted to the

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On July 19, just prior to starting as the Director, one of the previous DARPA directors counseled me. He said, “DARPA is one of the gems of the Nation. Take care of her.”

Which is really an elegant way of saying, Regina, this is important, don’t screw it up.

Madam Chairwoman and Members of the Subcommittee… My name is Regina Dugan, I am the Director of the Defense Advanced Research Projects Agency. I am proud to be here. And I am clear about the weight of my responsibility. I share this responsibility with an outstanding Deputy, 7 capable office directors and their deputies, dedicated military liaisons, 101 spirited program managers who are the soul of the Agency, and a comparable number of support staff who embrace a “we’ll find a way” work ethic. Our responsibility is to our warfighters and to the technological superiority of the Nation’s defense. Frequently, the resulting innovations also contribute significantly to the Nation’s economic vitality. We challenge existing perspectives, break china, and make people excited and uncomfortable, sometimes with the same sentence. You might say that DARPA is the Nation’s elite army of futuristic technogeeks. And this is our service to country.

I am also clear that there is a fine line between pride and self-congratulation. As you are well aware, over the 50 years of its existence, this Agency has achievements ranging from the Internet to stealth, from GPS satellites to MEMS technology, from rockets to the M-16 rifle. We like to refer to these accomplishments. Often. We all feel proud of that rich history. Indeed, this spectrum of accomplishments, over half a century, is so impressive that many have sought to emulate the DARPA brand. And we have, ourselves, sought to understand the underlying elements responsible for this long string of successes. We discussed the essential elements of this success at the January 7 meeting of the President’s Council of Advisors on Science and Technology. Namely:

- A commitment to working at the intersection of basic science and application.
- The steadiness in funding that results from the Government’s responsibility to provide for the Nation’s defense, and our role in so doing.
- The focus, urgency, and breadth of solutions required to serve Defense needs in austere, life-and-death situations.

These essential elements call for our best and brightest. For boldness. And they focus the mind. They give rise to DARPA.

But, I want to be straight. Understanding the instrument is primarily a means for ensuring we well use and protect it. You should expect this of me and of the Agency. I get that. And I agree. Further, articulating past successes is a confidence builder both for us and for you. It suggests that the Agency should be afforded some flexibility. Because the future impact of bold new ideas often cannot yet be understood, and capitalizing on advances often requires changes on short timescales. But we should avoid the error of self-congratulation. It is indulgent. The spectrum of challenges we face now and into the future is vast. The challenges are too big to do it alone. And we've got too much to do to rest on past successes or an outstanding reputation.

In support of our budget request, today I will talk about our contributions to the current fight; these contributions are measured in efforts over months and in investments over years. I'll turn to our ongoing programs because these are the seeds that promise to impact next-generation capabilities. And we'll talk about what's next by describing novel initiatives that challenge our conventional thinking and address some of the most complex problems of our time.

We recognize that we cannot achieve great things alone, and so I will also address our efforts to engage the best talent in the country from universities to industry (small and large) as well as our partnership with the Services. It is said that "Ambition is a dream with a V8 engine." So, I'll conclude by highlighting our recent efforts to fine-tune the engine. Because execution is what turns dreams into reality, the Agency must operate with agility, speed, technical and administrative integrity. It's the horsepower that allows us to make that which we imagine… real. Today and into the future.

Let's start with the current fight. It's on our minds.

We are supporting operations in the current fight. I have just returned from Afghanistan and it is clear that there is no shortage of challenges. This is an insurgency; IEDs are the weapon of choice. It is a coalition fight; and we seek transfer of responsibilities to the Afghans. Technology plays a role across this spectrum and DARPA contributes through both short-term responses and the realization of efforts started years ago. Two recent efforts, HALTT and Crosshairs, are directed at the challenge of protecting helicopters and ground vehicles in

theater. We dramatically accelerated the fielding of these technologies in close collaboration with DDR&E and the Services.

The Helicopter Alert and Threat Termination (or HALTT) program addresses the need for hostile fire indication of incoming small arms fire, which account for 85 percent of hostile fire engagements. HALTT uses advanced acoustic detection and data processing to exploit the supersonic shock wave produced by a bullet in flight. The system alerts the crew to an attack and provides shooter location with "o'clock" accuracy. A prototype HALTT system has been installed on an Army UH-60 L Blackhawk helicopter, which underwent air worthiness and performance testing just last month. Soon, we will deploy several systems to Afghanistan for operational evaluation. From funding allocation to live fire test completion, this effort took an unprecedented 5 months and will be fielded in less than a year from identification of the need.

Similarly, the DARPA Crosshairs program will develop and validate technologies to protect ground vehicles in Iraq and Afghanistan from small arms, rocket-propelled grenades (RPGs), and other advanced threats. Crosshairs detects, classifies, and backtracks threats. It will geolocate and display shooter position on an interactive map and then slew-to-cue an overhead weapon based on user inputs.

Both HALTT and Crosshairs promise to make it very dangerous to shoot at US Forces. Because the first shot may very well be the adversary's last.

Some assume that the nature of preventing or creating strategic surprise suggests that we cannot contribute on the timelines required to support current operations. Not true. HALTT and Crosshairs illustrate that we can help. At any point in time, DARPA has technologies in all stages of development: from nascent idea to system ready for fielding. Second, I do not believe that strategic surprise observes predetermined timelines. Indeed, strategic surprise can occur on any timescale. We get a vote. And so does the adversary.

The evidence of these basic tenets is in the Agency's history. DARPA has been involved in support to active conflicts since the Vietnam War. When the country is at war, and we can contribute, we are obligated to do so. It is our duty. Defense systems must work. Period. Not only in the most benign environments, but also in the most austere… on the sea, in the mountains, in jungles, with sand, dust, or water. Anytime, day or night. Under life and death

conditions. I believe that this breadth, urgency, and technical demand must be real to focus the mind. This authenticity inspires greater genius. And it cannot be created in the abstract.

We continue to be committed to contributing, where able, to the current fight. My trip to Afghanistan reinforced this commitment and suggested a number of potential options that we are investigating. Not surprisingly, DARPA's work is unusual in texture and character. Less about response to already articulated needs than observations of opportunities not yet conceived, these efforts are nevertheless well-aligned with other, often heroic efforts, within DDR&E and various rapid response programs within the Department.

We must balance this investment with our responsibilities to the next generation of warfighters. The importance of striking this balance can be seen in the current theater of operations, because many of the technologies in use in today's fight were once DARPA programs.

There was a time, not long ago, when it was considered inconceivable (or at least ill advised) to fly an aircraft without a pilot onboard, let alone that there could be a system that fulfilled the entire kill chain – from finding and fixing, through tracking and targeting, to engaging and assessing.

Today, in all likelihood, a small patrol of Marines in the Helmand province is faced with dangerous uncertainty about what lies just beyond their limited, earthbound line-of-sight. The complex environment in which they must operate provides ample concealment for potential adversaries. Today, that patrol has options. They may choose not to accept the risk inherent in moving blindly around the next corner, behind the tree line, or over the ridge. They might choose instead to launch a tiny airplane called WASP, which gives them a birds-eye view. WASP allows them to see what was previously unseeable. Equipped with "binoculars in the sky," the patrol may be able to avoid a potential ambush site and, instead, surprise the enemy.

Elsewhere in Afghanistan, a commander receives critical information concerning the movement of enemy forces staging for an attack. The information comes in the form of high-definition full-motion video giving him both the detail and the critical time necessary to make a sound decision. Unseen and unheard, the silent sentinel is directed to train an unblinking eye on the enemy combatants and track their every move while friendly forces prepare a response. The

silent sky sentinel we now all know as Predator prepares US and coalition forces and then records the results of a successful engagement.

The UAV capabilities deployed on the battlefield today started in DARPA in 1984 with Project Amber, the original goal of which was to create a long-endurance, low-observable UAV with sophisticated sensors for photographic reconnaissance and electronic intelligence missions. From the small WASP to the Predator to Global Hawk, these systems now number hundreds in Afghanistan and Iraq. What once seemed impossible has become routine. In the very near future, the United States Air Force will train more UAV pilots than conventional pilots, and today we talk about "blackening" the sky with such systems.

This progression characterizes many of DARPA's advances: first impossible, then improbable, eventually inevitable.

The Autonomous Real-time Ground Ubiquitous Surveillance - Imaging System, or ARGUS-IS, is a next-generation airborne capability, providing wide-area, high resolution, color video imaging that enables persistent surveillance of dynamic battle spaces and urban environments.

The system consists of three elements: A 1.8 billion pixel video sensor that runs at video frame rates to support tracking of both ground vehicles and dismounted targets. When videos representative of Constant Hawk and Argus-IS capability are compared side by side, the benefit is clear; even amateurs can more quickly and unambiguously identify dismounts. And the easing of this analysis task for humans is mirrored in the easing of the analysis task for the computer. The reliability of automatic tracking algorithms improves, thus enabling a first step toward relieving the pressure felt by the data volume.

The USAF and DARPA will be conducting a final series of test flights this summer as part of the transition of ARGUS-IS to the Wide Area Airborne Surveillance (WAAS) program. ARGUS-IS is currently being evaluated for readiness for inclusion in funded Quick Reaction Capability (QRC) programs.

The Integrated Sensor Is Structure (or ISIS) program is advancing theater-wide surveillance, tracking, fire control, and engagement through the technology development, integration, and flight demonstration of extremely large, lightweight radars embedded in the structure of station-

keeping stratospheric airships. The size of a 15-story apartment building and operating on multiple frequencies, these large unmanned airships promise to provide extremely long-range continuous surveillance, individual target tracking, and engagement guidance for all air and ground targets, to include extremely small cruise missiles and UAVs, insurgents and guerilla forces, and small vehicles operating under foliage – capabilities not possible using existing or planned air or space assets.

The range of potential applications is wide, from maritime surveillance to ballistic missile and homeland defense. Logistically resembling a satellite, such a fully-regenerative solar-powered airship may be able to provide decade-plus operation at significantly reduced costs compared to present systems. If successful, a single station-keeping ISIS near Karbala in 2000 would have afforded coverage of the No-Fly Zone in Iraq at less than 5 percent of the $1.4 billion Southern Zone operation and sustainment.

So, our charge is two-fold: When possible, provide solutions in support of current operations, and invest in next generation capabilities. The Agency's future investment is broad, ranging from hypersonic vehicle technologies to vaccine production using tobacco plants.

The Falcon program is in the final stages of preparing for the first U.S. flight test of a long-range hypersonic, boost-glide vehicle. During this past year, the program successfully completed the assembly, integration, and ground testing of the first flight vehicle as well as planning and preparations for the first flight test. The system will be launched on a Minotaur-IV and, following release from the booster, is intended to fly approximately 3,000 nmi within the atmosphere to a terminal impact point north of the Kwajalein Atoll.

The program seeks to demonstrate unprecedented maneuverability, atmospheric flight time at hypersonic velocities, and critical capabilities supporting prompt global reach. It represents the seminal flight demonstration for the OSD Defense-Wide Conventional Prompt Global Strike initiative and is the foundation of planning to meet the US Strategic Command's Precision Global Strike requirement. It is a pathfinder program for the USAF Conventional Strike Missile Program and is expected to transition core technologies to other efforts within the Services.

Speed matters not only in global strike, but also in our response to a biological attack. Whether the attack is engineered or a naturally occurring pandemic, the Accelerated Manufacturing of Pharmaceuticals (AMP) program at DARPA utilizes recent advances in genetics, gene-transfer techniques, and specialized plant strains in sterile, automated facilities to demonstrate a radically different approach to the pharmaceutical manufacturing of flu vaccines. Such an approach would permit production ramp-up or redirection in response to a viral resortment in 30 days rather than 3 to 6 months and is independent of conventional egg-based, capital intensive, vaccine manufacturing approaches currently in use.

The potential success of AMP rests on previous advances made at DARPA. In March 2009, a Navy medical team received information on an (unknown) strain of influenza. Using previously developed DARPA technology, the team identified the strain as being H1N1. The DNA sequence was identified and transmitted electronically to the DARPA AMP facility. A “live fire” test was performed and protein (vaccine in its raw form) was produced from plants in less than 4 weeks. This rapid response was made possible because plant synthesis of the protein only requires the sequence and not the actual virus. The plants act as highly efficient drug factories producing the subunit protein (vaccine) which is then purified using established techniques.

We are pursuing two, complementary paths to establish this capability for rapid, responsive vaccine production. First, a small pilot facility will produce a vaccine-grade recombinant protein for formulation, immunogenicity, and toxicology studies. Data from those studies should lead to the filing of an investigational new drug package and clinical trials, the results of which are needed to consider potential approval of this vaccine under an emergency use authorization. Second, we will seek to demonstrate scale-up of the plant-based platform to 10 million doses per month. Together, these efforts could give the Department and the Nation an agile and flexible capability to neutralize natural or intentional pandemic disease. And, in cooperation with partners in other Agencies, DARPA’s umbrella program, called Blue Angel, promises to provide the elements necessary to significantly thwart the biological terror threat.

It doesn’t stop at systems we can see... the work at DARPA also encompasses nanoscale systems and those that exploit quantum mechanical effects…

Thin films of graphene are carbon nanotubes unrolled. They are single-atom sheets of carbon, one-third of a nanometer thick, that were used in devices as part of DARPA’s nanotechnology

efforts. A nanometer is 1 billionth of a meter or 1 million times smaller than a grain of salt; it is the distance your nails grow in 1 second. These thin films promise to break through the 50-year-old limitations of traditional silicon microelectronic devices. Recent advances in carbon-based electronics would enable devices that have 10-fold higher operating frequencies and 100-fold lower power over silicon-based electronics. Imagine wireless devices that transmit HD video as effortlessly as voice and extend the operating time of our laptops and mobile phones from hours to days. In Defense applications, this means radar systems with 10-15 times the current range. Imagine being able to probe enemy assets at distances that put our platforms and warfighters well outside the reach of adversary systems and weapons. Interrogation or release of a weapon system is possible before the adversary can employ countermeasures. It's like having a really good right hook at the end of a 50-foot arm.

And because the intersection of basic science and practical application characterizes almost all that DARPA does, we pay careful attention to implementation. As we often articulate, advances in science are necessary, but insufficient. Our interest is in realizing the promise in such advances to create new capabilities. Advances in nanotechnology or nanomaterials have often resisted practical implementation in systems. This is in part because they are difficult to manufacture. As an example, we all know that production of silicon microelectronics is capital intensive. Investment in new manufacturing facilities can require billions of dollars. It's a big risk and a big barrier to overcome. So what's different about these recent advances at DARPA? These thin film layers of graphene can be directly incorporated into existing microelectronic fabrication methods, leveraging the decades, and the billions of dollars of investments, in silicon microelectronics manufacturing facilities.

The Quantum Effects in Biological Environments (QuBE) program poses a quintessential DARPAesque-style challenge. Namely, that biological sensors are not governed by "classical" physics at all. That this conventional world view is wrong. Rather, that quantum effects are necessary to explain the exquisite performance of biological sensors, which display high sensitivity, selectivity, and low false alarm rates, yet operate in dirty, noisy natural environments. Recent evidence suggests that the exploitation of manifestly quantum mechanical (or subatomic) effects would allow us to unlock the mysteries of a bird's magnetic field sensing used for navigation, the canine's keen sense of smell, and the highly efficient energy transfer properties of photosynthesis in plants. To date, we have failed to produce synthetic sensors

that mimic biological capabilities. Perhaps there is a whole new world of sensing on the other side of this question.

Sometimes it's not about what we can see, but what we can touch and feel.

Perhaps one of the most publicly recognized programs at DARPA is our advanced prosthetics program. The goals of the Revolutionizing Prosthetics program are two-fold: to provide an arm with a range of motion and dexterity comparable to a natural arm and, eventually, provide an arm that permits the same sensory experiences as a native limb. Currently, a neurally-controlled arm is undergoing qualification for its ability to restore tactile feedback to the user in a way that feels natural. Eventually, we envision an arm that will also allow the user to feel temperature and joint motion. We believe that together these features will restore functionality to the user that approximates that of their original, native limb.

Last year, I had the privilege of meeting Fred Downs when he visited DARPA to demonstrate his use of one of the new arms. Fred lost an arm in the Vietnam War and has been using a conventional prosthetic ever since. His command of the new arm was impressive. But what struck me most was the story he told of his own reaction to wearing it. He said that after a very short time, he was surprised by his sudden emotional response. Because, he realized that he was thinking like a bilateral again. For the first time in 40 years.

It was remarkable.

The advanced prosthetics program is part of a collection of programs at DARPA devoted to the care of our Service men and women. We seek to develop capabilities that help to stop blood loss, diagnose and treat traumatic brain injury, and assess those at risk for suicide. Our commitment to them is one way that we honor their commitment to the Nation.

So, what's next?

One of the biggest challenges we face as a Nation is the decline in our ability to make things. Americans today consume more goods manufactured overseas than ever before …and yet they are less likely to be employed in manufacturing than at any time in the last 100 years. In the

early 1940s, the manufacturing industry employed nearly 32 percent of American workers. By 2000, the industry employed only 13 percent of American workers.

There is much debate and discussion about the reasons: increased productivity, a decline in our S&T talent, currency manipulation, and trade policies. It is a complicated issue. But I believe we have come to appreciate the truth in Jeffrey Immelt's letter to the GE shareholders in 2008. He challenged the 30-year notion that the United States can prosper by moving from a technology and manufacturing leader to a service leader. He went on to say that *"…our businesses, our government, and many local leaders [have] lost sight of what makes a nation great: a passion for innovation…To this end…the ability to innovate must be valued again. We must discover new technologies and develop a productive manufacturing base*."

At DARPA, we have developed a short hand for this… we say, "to innovate, we must make."

What does it mean for our Nation's defense, specifically? Adam Smith famously warned that "*if any particular manufacture was necessary, indeed, for the defense of the society it might not always be prudent to depend upon our neighbors for the supply*." From the U.S. Civil War to the Second World War, industry's criticality to national defense has been demonstrated time and again. In World War II, the manufacturing burden for the United States and its war-torn allies was carried by American factories. These factories mass produced the aircraft, ships, land combat vehicles, and other vital support equipment instrumental to the Allied victory.

Not only is it true that to innovate, we must make. It is also true that to protect, we must produce. The parallelism is profound.

The Deputy Director, Dr. Gabriel, and I both came to DARPA from organizations that made things. We both know, at a visceral level, how difficult it is to make new products. We asked ourselves the following question: What is the fundamental technical challenge in making new things? And we concluded: It is in the seams. The seams between each 'stage' of development… design, prototyping, early production runs, limited and large-scale manufacturing. Seams between stages require extensive rework and are the source of production delays, surprises and cost overruns.

So, what if we could erase the seams? What if, rather than trying to create increasingly sophisticated prototypes, we could undertake large scale manufacturing in quantities of one? What would this imply? And is there an existence proof?

There is, in fact. The existence proof comes from the semiconductor industry and, in particular, fabless semiconductor companies. All semiconductor companies produce prototypes of new products/chips in exactly the same foundries that are used for large-scale manufacturing. Vertically integrated companies produce prototypes and move to large-scale manufacturing in the same, captive fabrication processes and facilities. Fabless semiconductor companies not only produce prototypes and move to large-scale manufacturing in the same fabrication processes, but do so without the need to own the fabrication facility. The nature of semiconductor fabrication has enabled the emergence of a business model and rationale for semiconductor foundry companies— companies that do not manufacture products of their own, but instead only provide large-scale manufacturing to serve as efficient makers of products, distributing the cost of expensive manufacturing facilities across thousands of semiconductor products designed by hundreds of fabless companies.

This change was enabled by the insights of Mead and Conway in 1979. Mead and Conway wrote design rules and component models that were independent of manufacturing processes. Admittedly, some initial compromise was necessary in performance. But the resulting scale of innovation made possible by the sheer numbers of designers yielded advances that far surpassed those initial compromises.

The semiconductor industry experienced a period of explosive growth when the design process was decoupled from the manufacturing process, when the means by which we produced became rapid, cost effective, and seamless. In the semiconductor industry, hundreds of designers became tens of thousands. And students could access manufacturing lines for prototype runs in weeks at costs of hundreds of dollars. In the IT industry, similarly, higher levels of programming abstraction associated with the move from assembly code to Fortran, and the advent of personal computing, erased seams and increased accessibility.

Importantly, such a model represents high value-added manufacturing – where innovation and unique capability (not cost of labor) is the competitive advantage. It is the ultimate prize coveted by industrial leaders across domestic and international manufacturing industrial bases.

Our current investment in manufacturing innovation at DARPA totals approximately $200 million per year, or $1 billion over the next 5 years. We are synthesizing and integrating these efforts so as to contribute alternative design and production methods for next-generation systems. DARPA seeks to create breakthroughs in manufacturing that enable new innovations much like the breakthrough of the Internet enabled massive innovations in the communication and IT industries.

Which brings me to my last point: Because this type of massive innovation – in essence the democratization of innovation – has both risks and opportunity.

And in a world that is hyper-connected, socially networked, and global, the risks and opportunities are more extreme.

We often talk about globalization as a world without boundaries. But if you speak with a sociologist for even a few minutes, they will tell you that as long as humans are involved, there are boundaries. There are boundaries between men and women, between people in and out of uniform, between socio-economic classes, religions… What is different in a globalized world is that those boundaries, or edges, no longer conform to geographic lines on a map. Our ability to define these edges, from a technological and a policy perspective, has not yet evolved. Nowhere is this felt more acutely as a threat than in the cyber world. Nowhere is this felt more acutely as an opportunity than in the global mindshare of democratized, crowd-sourced innovation.

Social networks are powerful. They are poised to transform our society. There are many examples of emergent, coordinated behavior in social networks, as in the contributions to Wikipedia or Trapster or North Korea Uncovered, as well as social networks used as tools to organize large groups of people with common interests, as in the 2008 US presidential campaigns and in the protests following the 2009 Iranian presidential election.

Trapster. Trapster is an application for getting speed trap alerts on your Blackberry, iPhone, Nokia, Android, Windows Mobile, Palm Pre, Garmin, or TomTom device. The application crowd-sources the identification of speed traps. Smartphone users identify and map speed traps in real time on their phones. The application averages 6,000 new traps reported every day. In

order to ensure the reports are accurate, Trapster's "Trapologists" constantly monitor the trapmap and evaluate each trap. Recently, local police departments have also gotten involved. The Travis County Sheriff's Office in Austin, Texas, is now entering its own enforcement locations, as well as other information such as dangerous intersections, road closures, accidents, and traffic jams. Trapster gets drivers to slow down – which is, ultimately, the goal.

North Korea Uncovered. On Google Earth there is an image of North Korea, annotated by 35,000 people who logged on and identified locations of interest including military installations. In this mash up, regular citizens use social networks to make one of the most secretive regimes in the world amazingly transparent.

"North Korea Uncovered" challenges our very notion of truth. Our traditional worldview describes truth as that which can be authenticated by source. If we can authenticate the source, we set the bit as true. The information may still be erroneous, but we assign it to truth. Truth defined via social networking is different. It is regression to the mean and time changing. It is influenced by what we do and what we don't do. The mechanisms and tools we use to assess truth are different. And this truth, thus, requires a different world view.

Network Challenge. On December 5, 2009, DARPA began our exploration of these concepts. Namely, the power of social media to find things and the difficulty of assessing truth. The DARPA Network Challenge was a social network mobilization experiment to identify distributed mobilization strategies and determine how quickly a challenging geolocation problem could be solved by crowd-sourcing. Ten numbered, 8-foot, red balloons were simultaneously launched and moored in parks across the contiguous United States. The first person or team to report to DARPA the correct locations of all 10 balloons was awarded a $40,000 prize. A total of 4,367 individuals registered in the DARPA Network Challenge. To our knowledge it was the first large-scale social media experiment that included some adversarial component and significant efforts were devoted throughout the challenge to spoofing and masking the truth.

The winning MIT team correctly reported the location of all 10 balloons in an astonishingly short 8 hours and 52 minutes using a constructed and motivated network exceeding 5,000 individuals from just 4 initial nodes in less than 2 days. Indeed, we observed that social networks emerged or mobilized very quickly to solve this challenging geolocation problem. A significant number of the top finishers launched their team mobilization efforts with only a 1- or 2- day notice. Teams built around existing networks were able to mobilize their networks in less than a day. In one

case, a highly connected individual successfully mobilized his contacts through Twitter in less than an hour. Equally impressive, many of teams were able to do precise, targeted dispatching to verify balloon tips.

The DARPA Network Challenge revealed several promising means for using social networks to mobilize groups of people for a specific purpose and demonstrated the speed at which social networks could potentially be used to solve challenging, national geolocation and information-gathering problems.

Transformative Apps. Our next step will be focused on harnessing massive innovation in the development of applications ("apps"). Today's military handhelds, and the supporting network infrastructure, are designed to be highly robust and secure. Unfortunately, they are also fairly inflexible and very costly. New applications, and modifications to existing applications, can take years to field. Development is hampered by tight integration of hardware and software that is often generations behind commercial technology. Further complicating matters is the standard DoD practice to segregate users, requirements, and procurement in a highly disciplined process that does not permit a quick reaction in the face of rapidly changing user needs.

The goal of the Transformative Apps program is to place the right mobile software applications into the hands of warfighters as the apps are needed. As a result of this program, a diverse array of apps of national security relevance will be realized using an innovative new development and acquisition process. A military apps marketplace will be created to enable rapid innovation to meet user needs based on a direct collaboration between a vibrant and highly competitive development community and involved communities of end users. The program will address all the challenges – technical, business, and operational – to make the new capabilities available for use in the field. The objective is to transition the resulting systems to the end users in the Services and to foster a new model for rapidly and effectively acquiring, introducing, maintaining, and enhancing software.

As part of creating a military apps marketplace, DARPA will aggressively explore business models that can support the effort and provide alternatives to the traditional acquisition paradigm. New business arrangements and processes will be created that encourage broad participation from numerous development teams. We will explore appropriate rewards for the developers that are based on number of downloads, usage statistics, or other measures of

value to end users. The program will also explore alternative models for sustaining and enhancing the software in an efficient and cost-effective manner. Upon release of the Broad Agency Announcement, a buzz started. We counted 1 tweet a minute for 24 hours. Crowd-sourced, massive innovation of military applications the subject of over 1400 tweets? First impossible, then improbable. Perhaps sooner than we realize…inevitable.

This set of programs and ideas is almost overwhelming in scope and potential impact. But they are not ours alone. Rather, they are the result of vibrant exchange among many. One of the Agency's strengths is its ability to build bridges between disparate communities and to uncover ideas in unexpected places.

Over the last 6 months, we have renewed our commitment to this ethic. We have aggressively engaged with three important constituencies: universities, industry, and the Services.

Over the last few years, the University community has articulated concerns about DARPA's commitment to basic research. There was much said on both sides about the veracity of these concerns. As I described previously, one of the elements of DARPA's success is the Agency's commitment to work at the intersection of basic science and application, so-called Pasteur's quadrant. The tension created in Pasteur's quadrant arguably serves as a catalyst for innovation. DARPA is not a pure science organization, but neither are we a pure application organization. We sit firmly at the intersection of the two and, to be successful, we need the minds of the basic scientist and the application engineer, those in universities, and those in industry. And we need them working together, often on a single project, in the cauldron created by the urgency and technical demands of Defense. This is almost a unique characteristic of DARPA projects, which are often multi-discipline, multi-community, and multi-stage.

University Outreach.

Upon arrival at DARPA, we were determined to understand and repair the breach with universities. We discovered the following: Between 2001 and 2008, DARPA funding to US research university performers did decrease in real terms, by about half. But, as importantly, a noble and recent focus in the Agency on solving nearer term problems for the Department had resulted in some additional, perhaps unintended, consequences. The nature of the work

changed, from multi-year commitments, to those with annual “go, no-go” decisions governing continued funding, which made it difficult for universities to commit to graduate students. A later stage focus resulted in more work done by universities as subs to prime contractors responsible for integration efforts, and the resulting flow-down of restrictions on the use of foreign nationals, export control, prepublication review, among others.

We assessed that we could address many of the concerns identified. So last September I traveled to five universities – Texas A&M, Caltech, UCLA, Stanford and Berkeley – to meet faculty, deans, and presidents, graduate students and undergraduates. The goal was to speak honestly and directly with them. We laid out the concerns, as we understood them, and the changes we had made or intended to make. We asked for their feedback. And we asked for their renewed commitment as well. For researchers to renew their commitment to working on Defense problems. For university leaders to clear obstacles and encourage their best and brightest to serve in Government. This service is, of course, in our shared self-interest because the quality of Government research sponsorship goes directly as the quality of the program leadership.

We continue to work on the issues: by educating our program managers to include basic research as an element in their programs, where appropriate, and to protect the integrity of this work under the provisions afforded fundamental research. The Agency has instituted new processes to ensure the necessary elements of academic freedom in basic research are balanced with the responsibilities of national security concerns. And we have increased transparency so that researchers can quickly determine whether restrictions apply to their work.

Since September, we have visited additional campuses across the country and spoken with university representatives to include Virginia Tech, Georgia Tech, MIT, and others. Our dialogue continues with more than 100 schools. We have more work to do, on both sides, but so far, it seems as if the breach is healing.

Industry Outreach.

Equally important, of course, is the role of industry: From electronics to pharmaceuticals, software to space, small businesses to large. On January 26th and 27th of this year, DARPA held an Industry Summit, the goal of which was to engage the leadership of US industry: CEOs, CTOs, COOs, and senior VP-level executives. These industry executives – 60 percent of whom were from small businesses – represent some of the best minds in the country. Our thought was that it would be productive to enlist them in the characterization of problems facing Defense of the Nation and in the generation of ideas.

More than 120 companies – Defense and non-Defense, representing more than 10 business sectors – participated in roundtable discussions regarding how competitiveness is affected by globalization and the implications for National Security. The discussions concerned the barriers to innovation, access to science and technology talent, and Government/industry relationships. The days were long and the discussions were animated. Perspectives were refined, discarded, shifted. We gained insight as did the participants.

Interestingly, we identified novel possibilities in a variety of areas, such as STEM education. Participants suggested a "Box O' Radar," a kit for teachers to give students hands-on experience with radar systems. The vision is that the children would actually build and use simple radars with wavelengths large enough to physically measure. We contemplated simple Doppler radars for motion sensing as well as basic pulsed radars. Additional ideas included the development of an application "marketplace" devoted to STEM that would post challenges such as "apps to teach electronics" or "apps to teach radar" or just "coolest app with a practical use." Industries motivated to increase the basic knowledge level and proficiency on such topics would also sponsor prizes based on download counts and/or by technical judging. Prizes might range from iPod’s to scholarships.

Such initiatives might be interesting additions to existing STEM programs at DARPA, such as our Computer Science STEM Education program, which seeks to increase the number of students selecting computer science or a STEM major by providing age-appropriate, challenging activities and a sustainable infrastructure throughout middle and high school. Additionally, we sponsor InSPIRE, which utilizes microsatellites inside the International Space

Station as a platform for a series of student-led experiments and algorithm competitions, plus a crowd-sourcing experiment explicitly aimed at high school students.

Notably, industry had something to contribute to the STEM challenge. We discovered they are worried too and motivated to participate in the solution.

We had equally instructive exchanges on topics ranging from novel approaches to export control to cyber security. Participants had concepts for creating incentives that would better balance restriction of foreign access to key US technologies while ensuring the United States retains an industrial base for production. In cyber security, concepts for monetizing trust as a means for advancing our progress emerged.

The outcomes of the Summit were much broader even than these ideas and, admittedly, broader than we anticipated. Since it was an experiment, we did an extensive post-event survey of the participants. We contacted nearly every industry leader who participated. We learned that industry leaders valued the intensity of the exchange. They asked for a mechanism to continue the dialogue with the other Summit participants so as to continue to collaborate with each other. Further, nearly half of the participants told us that the Summit created the opportunity to build new business-to-business connections that they could not have imagined happening otherwise. An average of two participants at each table has already engaged in doing business together. DARPA served as the bridge.

Our Service partnership.

Our partnership with the Services might best be described as a collaborative competition. We get crosswise when either party thinks it is only a collaboration or only a competition.

It creates an environment much like that experienced by athletes, where competition serves as a means of identifying winning strategies, and collaboration is a means of honoring higher goals. We agree to this collaborative competition because it works. But it is not without its struggles. Sometimes intense rivalries emerge; sometimes a referee has to intervene.

When the Secretary of Defense visited DARPA, I told him that if we do our job well, we would make him both very happy and very unhappy. Very happy because in DARPA's reach for new

capabilities that create strategic surprise, we often have intermediate landing points that significantly improve operations now. Very unhappy because sometimes DARPA advances promise to upend entirely what the Department is doing now. The collaborative competition necessarily involves some pain. But, at its best, when the equation is right, it's a powerful partnership.

Limited budgets focus activities; two wars intensify needs. Understanding how best to weigh the Department's responsibility to the present without sacrificing the future is critical. And each decision to apply resources comes with an opportunity cost. We found ourselves struggling with these very issues just within DARPA. With more than 100 creative program managers, the problem was not new ideas. The problem was deciding among them. We needed a strategy for balancing conventional overmatch investments with those devoted to thwarting insurgencies and terrorism. We came to understand that we could contribute significantly to understanding the decision-making space for highly complex problems.

DARPA has arguably one of the highest densities of technical subject matter experts in the Government. As such, we should devote effort to the formulation of the analytical framework necessary to sort through complicated ideas and to identify both gaps and opportunities that will guide both our internal investment decisions, and inform our engagement with the Services.

We call these analytical frameworks portfolio reviews. To date, we have completed a few. Global integrated ISR and tactical communications. We have others in work to include cyber, the delivery of lethal effects at distance, PNT (position, navigation, and timing), energy, and logistics, among others. These portfolios attempt to frame the discussion in technical and operational terms.

Let me give you an example from our global ISR portfolio. There is a near-constant complaint that we are drowning in data. So, we decided to assess exactly what this means. We calculated data volume as a function of sensor resolution and area coverage and we compared the data volume required to accomplish certain operational objectives. For example, to see strategic bombers one needs resolution of approximately 10 m^2. Over an area the size of Reagan National Airport, this resolution results in a data volume equivalent to about 1 second of MILSTAR SATCOM. To see dismounts, however, one needs resolution of approximately 10 cm^2. Over an area the size of Baghdad, this is about equivalent to a data volume equal to 1

second of US Internet traffic in 2009. Not surprisingly, when we plotted existing and new or planned ISR systems, there was a general trend toward higher resolution and larger fields of view.

One of two things must happen: either we must give up the target set, or we must deal with the data volume. They are linked. Obviously, we do not want to give up the target set.

The trend driven by increasingly demanding target sets is driving data volume exponentially. We cannot solve this exponential problem with a linear growth in analysts. Our need is divergent from our capability. Specifically, if we examine the implications of CENTCOM requirements alone and a modest deployment of the new high definition ARGUS-IS described earlier, the number of analysts required increases roughly fifteen fold.

What's the solution? Counter intuitively but very DARPA-like, the problem has in it the seeds of the solution. The better sensors are not only creating more data, but *better* data. More and better data leads to better automation. Better automation enables better analysis.

As a representative example of what this means, ARGUS-IS provides video data at 10 times the frame rate. Ten times the frame rate means 10 times more data, but it also means that an automated system tracking a dismount or vehicle gets 10 times as many "looks" at the target as it moves. Increasing the frame rate makes the automated tracking both more accurate and less likely to lose the track. More data leads to better automation and, ultimately, to *less* of a load on an analyst.

Such tracking algorithms, in concert with more accurate image analysis enabled by higher resolution, can be trained to identify and flag, video verbs such as "digging," "unloading," and "walking"; allowing more and more of the analysis of existing and new ISR data volumes to be turned over to untiring 24/7 automated analysis systems. Not humans.

These automated systems will free humans to do what humans do best and leave computers to do what computers do best. This resulting amplification of this matching means that the analysts needed to address the data growth is radically reduced. The need is now convergent with the capability. And we didn't give up our target set.

We have briefed the global integrated ISR portfolio to the JROC, to USD(I), to military advisory groups, and other senior leaders on both the Military and civilian side, and we continue to get requests. It has become an important tool. It catalyzed important discussions about how we predict or know the point of diminishing returns of more data, it revitalized our approach to the data exploitation problem, and it has become the source of shared understanding. It has built more bridges between the technical experts at DARPA and those in the operational community. We better understand the problem and each other. Transition is still a struggle, but now it's a struggle over how best to achieve the goals of global integrated ISR. A collaborative competition over how best to achieve the best capabilities for the Nation.

This is but a part of an overall strategy to stay close to our Service partners. To date we have met with JFCOM, SOUTHCOM, CENTCOM, STRATCOM, TRANSCOM, and SOCOM. We meet with the VCJCS, the Service Chiefs and Vices, those in the supporting S&T functions, as well as civilian counterparts. Additionally, we have open conversations with members of the Army Science Board, the Air Force Science Board, the Defense Science Board, and the NRAC, among others.

Getting our business practices right is part of the job. No one remembers changes in business practices that enable success because they are, quite simply, enablers. Amplifying forces that allow us to achieve insanely great things. But getting them wrong can be a significant impediment. So, we have endeavored to be swift and aggressive about such matters. Since July 2009, we have:

- Wrung several weeks out of the procedures needed to get funds and supporting documentation to our contracting agents. This means that programs are underway, not languishing. And we regularly scrutinize programmatic and financial execution in each office to ensure we identify trouble spots early.

- Created an aggressive execution structure by shifting execution authority back to the program managers. Thus streamlining our decision making processes and putting DARPA program managers back in the role of running their programs in their best technical judgment.

- Stood up the Adaptive Execution Office (AEO) to harness the creativity of DARPA Program Managers and America's science and engineering community in the transition of DARPA technology to warfighters. AEO is about organizational relationships that connect warfighters to DARPA technology developers. The office is also taking a look at the transition worthiness of technology every step of the way, from inception to execution. AEO monitors the transition of programs and maintains a corporate memory of lessons learned. AEO provides support to current operations and is the primary interface with rapid fielding organizations across the Department.

- Created the Transformational Convergence Technology Office (TCTO) to explore emerging technological and social trends. TCTO focuses on the opportunities and threats of distinct, rapidly changing technology convergences. TCTO's research and development thrusts are interdisciplinary, spanning computing and computing-reliant areas of the social sciences, life sciences, engineering, and commerce. TCTO was responsible for the DARPA Network Challenge and continues to challenge the Agency's existing practices. They have spearheaded a pilot program on iPhone and Android use and, on February 27, started a contest to crowd-source the design of the TCTO logo. Over the course of 12 days, the staff provided feedback to 40 designers and reviewed more than 160 designs.

- Streamlined our SBIR contracting, creating what amounts to an SBIR "EZ" contract that utilizes commercial best practices and appropriate authorities. This removes significant barriers to the participation of small businesses in DARPA programs. It serves as a model for other Federal agencies.

And the list goes on…

Conclusion.

While we recognize the importance of measures of success, we also recognize the importance of wonder. DARPA has long been a place that nourishes wonder. Our recent Network Challenge captured the imaginations and wonder of many. I would urge you to go to YouTube and see the magic it created. It surprised even us. As humans and as a Nation, we need this sense of wonder. We crave it as children and as adults.

Forty years ago, the Internet was but a dream. We wondered… what's possible? Today, the Internet is commerce… it is a communal mind… the Internet is both vulgar and sublime. It has become a reflection of us, the human race…a vast, networked mirror that shows what we are and what we will become. And it has introduced a new generation of wonder in the power of social media, as experienced in balloon challenges, in the ability to transmit the bits that govern the organization of atoms in new vaccines. It has erased boundaries between people. It has created a new human geography, the implications of which we have only begun to understand.

What was once impossible, then improbable, and then inevitable. This progression characterizes DARPA's history, present, and future. The challenge serves as a timeless calling and source of wonder for the organization, for those in it, and for those near it.

American educator and poet, E. Merrill Root, is credited with saying "We need a renaissance of wonder. We need to renew, in our hearts and in our souls, the deathless dream, the eternal poetry, and the perennial sense that life is miracle and magic."

DARPA is the Nation's elite army of futuristic technogeeks. They are dreamers with V8 engines. This is their service to country.

Thank you.