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Statement by

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Mr. Chairman, Committee Members and staff: I am Dr. Brett Giroir, Deputy Director of the Defense Sciences Office (DSO) of the Defense Advanced Research Projects Agency (DARPA). I am pleased to appear before you today to discuss DARPA's vision for the future of amputee care, a vision we are proud to be pursuing collaboratively with the Walter Reed Army Medical Center (WRAMC) and the Department of Veterans Affairs (VA).

Our vision is simple but bold: to drastically improve the quality of life for amputees by transforming current limb prostheses into biologically integrated, fully functional limb replacements that have normal sensory abilities. Our goal is for amputees to return to a normal life, with no limits whatsoever, with artificial limbs that work as well as the ones they have lost. DARPA's vision includes not only regaining fine motor control, such as the ability to type on a keyboard or play a musical instrument, but also the ability to sense an artificial limb's position without looking at it, and to actually "feel" precisely what the artificial limb is touching.

A major caveat is in order at this point. We are in the early stages of this research and it will take considerable time to fulfill the vision completely. But the only way to achieve the vision is to move towards it.

Let me begin by saying a few words about DARPA and the Defense Sciences Office.

DARPA is a research agency within the Office of the Secretary of Defense with a special mission: to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security. DARPA does this by sponsoring high risk, high-payoff research that bridges the gap between fundamental discoveries and their military use. As a result of this mission, DARPA has a tradition of sponsoring research that a first glance seems like science fiction, but that eventually becomes everyday fact. The most widely known examples of this are the Internet and stealth technology.

Within DARPA, my office, the Defense Sciences Office, is focused on fundamental research in the areas of physics, material science, mathematics and, more recently, what we have termed the "Bio-Revolution" – a broad effort to harness insights from biology to make U.S. warfighters and their equipment safer, stronger, and more effective. Our vision for amputee care came directly out of this work.

Specifically, our vision stemmed directly from two of our programs. The first program, called Fundamental Research at the Biology: Information Science: and Microsystems Interface (BIO-Interfaces) established interdisciplinary research teams that combined biology, information science, and microsystems with the specific goal of developing novel computational tools to study biological systems ranging from single cells to the entire brain. In fact, Dr. John Donoghue, the lead neuroscientist at the new VA Center of Excellence at the Providence VA Medical Center, has received support from the BIO-Interfaces Program since 2001.

The second program, Human Assisted Neural Devices (HAND), has also been extremely successful. You may have seen some articles in the press about this last year. In this program, researchers supported by DARPA have demonstrated the ability to capture, process, and decode the electrical signals from thousands of individual nerve cells within the brain. What this means is that it is possible to decode brain signals in order to control the actions of an external device. Let me give you an example.

A monkey was trained to use a joystick to move a computer cursor while its brain cell activity was monitored. Eventually, the joystick was disconnected and even removed, and the monkey soon realized that it was able to control the cursor simply by using its brain directly, without the action of arm muscles or nerves. Perhaps more importantly, we discovered that the monkey had also learned how to use the decoding device to do what it wanted. In a sense, the monkey’s brain turned the equipment into an extension of the monkey, a new limb of sorts, if you will.

Viewing these results, an number of our researchers saw the promise for disabled people. What if improved decoding of neural signals, combined with the brain’s incredible plasticity and learning capability, meant that we could build devices, including prosthetics, that people could control just as naturally as they control their own limbs?

It soon became apparent that the DARPA BIO-Interfaces and HAND programs, as well as other DARPA programs on wound healing, sensors, information processing, multifunctional materials, and novel power sources could enable revolutionary new prosthetics. Realizing this, DARPA reached out to our colleagues at WRAMC and the VA.

We expect our relationship with the VA to be analogous to the relationships we have with the Military Services for most of our work. We focus on the high risk research needed for a breakthrough, which, if successful, will radically alter people's concepts of what is possible. When we do succeed, we always identify what we call a "transition partner" in the Services, an organization to perform the final phases of design, engineering, and when applicable, clinical development and testing. For amputee care, we are working with the VA and WRAMC in this same model. DARPA invests and develop high risk, high payoff technologies, many of which will be useful for prostheses as well as other military applications. These technologies will be transitioned through the VA Centers of Excellence for design integration, and clinical development and testing. DARPA and the VA Health System have an ongoing two-way collaboration.

DARPA also has a special relationship with WRAMC, where there is a growing clinical population of young, otherwise healthy amputees, who will be living with their disabilities for the next 5 or 6 decades. We visited these soldiers and they have provided our inspiration, and indeed fueled our passion, for this work.

So, our vision is clear. We will develop artificial limbs that will respond to an amputee's intent to move them just like a natural limb would. These artificial limbs must be biologically integrated and provide the patient with a clear sense of where the limbs are in space – that is, their position relative to the rest of the body. Moreover, the limbs must be able to transmit feeling and sensation back to the patient just as a normal limbs do.

To achieve our vision of prostheses that function like normal limbs, a tremendous amount of cutting edge research will be required in many disciplines, including neuroscience, microelectronics, control systems, materials, actuators, and power supplies. Ongoing examples are:

- First, we will continue to optimize our ability to detect and decode brain signals so that a patient can exert fine motor control over a prosthesis. Equally important, we will develop methods for a prosthesis to sense the environment, and then communicate that sensation back into the brain, so that the patient can actually sense where the prosthetic is and precisely what it is feeling. We also need to find ways to train people to use these new devices, to use the plasticity of the brain to make the prosthesis seem like a natural extension of the body. It is clear that this training will need to start as soon as the patient is physically able, in order to maximize the brain's ability to adapt and control its new appendage.

- We will continue to develop improved control architectures that combine centralized general control originating in the brain with local control based on sensors embedded within the prosthesis. Some of these architectures might benefit from elements that mimic reflex responses, so there could be simple actions that do not need to be directed by the brain.

- We need microelectromechanical (MEMS) devices both to sense and act on a fine scale. We will continue to develop a variety of lightweight, infection-proof materials to build the devices and provide an interface with the body that is much more comfortable and compatible than existing materials. We will also continue our work on novel materials that could serve as actuators by contracting much like our muscles do. And, our development of compact, lightweight, highly efficient power supplies, such as fuel cells, that can provide the energy needed to operate the prosthesis for prolonged periods of time without recharging will be a major input.

We have an on-going, robust working relationship with WRAMC and the VA. We have started projects at WRAMC that to lay the groundwork for the future. First, we are improving the collection and access to data on amputations and wound healing so that military clinicians and researchers can provide even better care to their patients. Second, we are developing and implementing a new training program for the control of prostheses based on virtual reality simulations. Not only do we expect to greatly expedite this rather arduous aspect of rehabilitation, but also make it far more interesting to new patients who must perform this training, repeatedly, day after day.

We have formed a number of working groups both inside of DARPA, as well as with the VA, WRAMC, and the academic and industrial communities to assure that our approach will yield the desired results. We have also hired a critical care neurologist, an Army Colonel who served in Afghanistan, to be the lead program manager of our HAND program.

There is a great deal of enthusiasm, and indeed passion, for this research inside DARPA. After personally visiting and interacting with our wounded soldiers, how could we experience anything but a heartfelt desire to make an important and lasting contribution? I fully expect that our current efforts will coalesce into a significant and growing research thrust for DARPA in the coming years – a thrust which we are primed to implement with our colleagues at WRAMC and the VA.

With that I'll be glad to take your questions.