"SBIR Successes: Small businesses bridging gaps"

Good Afternoon,
I have found that exploiting the SBIR program is one of the best ways to bridge the technology gaps that exist in DARPA programs.
At DARPA, I have managed a project known as the Augmented Cognition program.
The aim is to radically change the relationship between humans and computers in complex operational settings.
Occasionally, I run into a technical hurdle that requires innovative research and prototype development not covered under my original program plan.
This is precisely when I take advantage of the DARPA Small Business Innovation Research program: in order to tackle these very specific hurdles that might otherwise go unaddressed.
Today, I would like to share a few Small Business success stories resulting from my partnership with Ms. Connie Jacobs and DARPA's SBIR program.

The challenges addressed in the first phase of the Augmented Cognition program have given rise to a focused program on Improving Warfighter Information Intake Under Stress.
This effort has the explicit goal of enhancing human-computer performance in military settings through the sensing and analysis of the human's cognitive state in real-time.
An effort of this magnitude requires the development of closed-loop computational systems in which computers adapt to the current cognitive capabilities of the warfighter.
Information intake under stress implies that we are sensing brain activity, directly, and translating this data into information for cognitively demanding operational military systems.
Work in the laboratory has shown that remote recording from the brain is possible, but our interest is in detecting activity under stressful circumstances, in the battlefield, or in an operations center.
This program requires technological advancements over many fronts - and initiatives from the small businesses I work with have bridged both scientific and technological gaps as well as gaps along the path of providing the military services with real solutions to the challenges they face.

The "Improving Warfighter Information Intake Under Stress" program seeks to find the information processing bottlenecks inherent in militarily relevant human-computer interactions, and attempts to eliminate them.
These bottlenecks include limitations in attention, memory, learning, comprehension, visualization, and decision-making.
There are intrinsic restrictions in the number of mental tasks that a person can execute at one time and these limitations are dependent on mental fatigue, novelty, boredom and stress.
Having computers that adapt to military users in real-time will transform the human-computer relationship.
One can only imagine the information processing bottlenecks facing warriors controlling unmanned vehicles on tomorrow's battlefield or in the Net-Centric battlefield of the future.
Today we are working on the technology that will ensure we are prepared for tomorrow.

For decades, primarily in laboratory settings, researchers have investigated novel ways to image brain function in order to understand the human cognitive state, and the information processing chain.
As a result of these efforts, we are able to detect bottlenecks and devise strategies to aid users and improve their performance.
We would like to be able to perform the same functions, and at the same detailed level of understanding, and to assist users in executing tasks in the battlefield - not just in the laboratory.

Over the past two years, we have developed several SBIR topics to address these challenges.
The small business proposals that we have seen represent some of the most innovative and creative solutions to the challenges set forth.

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I want to tell you about four efforts that have contributed significantly to my program, each based on an SBIR topic.

First, let me tell you about Electrical Geodesics.
EGI is a world-class small business in Eugene, Oregon that has specialized in the development and production of high density electrode arrays for neuroscientific use.
However, in addition to the dense array devices they make - they also excel at real-time source analysis methods for detecting and mapping relevant signals from the brain.
In the field of neuroscience this is a particularly "hard problem" since without complex signal processing we can only detect signals at the surface of the scalp using Electroencephalography technology, but as we know, the brain is a complex 3-dimesional organ, with important signals emanating throughout its volume.
In their Phase 1 SBIR effort, EGI developed a gauge to measure working memory processes using their real-time source analysis methods.
This provided a fundamentally new capability: the detection of cognitive events related to information flow in real-time.
EGI is now working with Lockheed Martin and is applying their solution to the command and control environment.
The command and control environment is particularly taxing to the human operator; particularly the operator's working memory processes.
In their Phase 2 SBIR effort, Electrical Geodesics is refining the working memory gauge, and continuing the development of new cognitive gauges for other critical functions.
In addition, they are developing bootstrapping methods to accurately extrapolate data from many individuals without time-consuming baselines or training periods.
They've demonstrated flexibility and determination while maintaining the highest standards of scientific rigor; a key feature of all of my relationships with successful businesses.

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Human Bionics is a small business in Purcellville, Virginia that has worked on many wearable computing solutions over the past few years.
In their SBIR effort for DARPA, they are facing a truly unique challenge - mobile brain sensing.
Human Bionics is a leader in the field and understands the issues facing the recording of signals in the operational environment -- bridging the gap from

the laboratory to the battlefield. Researchers are typically accustomed to quiet rooms, motionless subjects, noiseless recording areas and lots of time in which to evaluate data. Unfortunately, none of these are present on the battlefield.

In their Phase 1 SBIR effort, Human Bionics has been "bridging this gap" by working on fully mobile electro-encephalography, or EEG device, for use in real-time in the field.

They are now working with Honeywell Labs to provide a wearable sensing system for the dismounted soldier. In their Phase 2 effort, they will further refine wearable sensing systems to make them even lighter and more compact, and advance the state of the art for noise cancellation from the data.

They plan to incorporate accelerometers and other devices that can sense the movement of the soldier, and compensate for motions that might affect the data.

By understanding the real world and the needs of the military, Human Bionics will transition cutting edge capability to the operational environment.

Both of the companies that I have talked about just now have been refining signal processing methods in order to make neurophysiological data usable for military situations.

But there is another approach to entirely redesign the way the sensors collect the information from the brain.

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QUASAR is a small business in San Diego, California that designs ultra low noise electronics for sensing, amplification, and communication.

Until recently, they hadn't considered the application of sensing of human cognitive activity. They responded to one of our solicitations with a radical non-contact electrode proposal.

They posed the following question: "What if the big problem with sensing and differentiating electrical activity in the brain is a contamination from signals emanating from the surface of the skin itself?"

They proposed a non-contact sensor design that would detect the electric field emanating from the brain, completely eliminating the contaminating signal from the skin.

If successful, it could be used to detect a variety of signals without touching the operator at all. In their Phase 1 SBIR, they showed amazing progress.

They were able to miniaturize the sensor down to the size of a dime and integrated their sensors into a common baseball cap to provide proof of principle that the neuronal signals could be detected using their system.

The sensors are inexpensive and entirely passive.

In their Phase 2 effort, they are further refining their sensor design so that it is more sensitive to biological signals, and increasingly wearable and wireless.

QUASAR's non-contact electrodes represent a critical bridge between the academic world and real world of military users - namely the need for noninvasive interfacing between the human and their systems.

QUASAR is now partnering with Boeing and their technology will be providing the latest sensors for use in their unmanned vehicle control station.

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NovaSol is small business in Honolulu, Hawaii that has been developing another novel sensor design.

NovaSol has pioneered optical designs for Defense applications for several years.
However, they have recently started to develop optical sensors for human systems applications.
Through their work using near-infrared sources, the scientists and engineers at NovaSol have developed an optically-based active imaging system that can detect and spatially localize brain activity in real-time.
Their near-infrared systems focus on cortical tissue through the skull, and can detect moment-to-moment changes in the oxygenation of brain regions - similar to those detected by fMRI.
The stimulant light is safe, and is reflected to the detector, yielding important information about where signals occurred.
In phase 1 of their SBIR project, NovaSol worked in collaboration with Dr. Denny Proffitt of the University of Virginia.
They were able to design a prototype system to detect activity in areas of the brain associated with speech.
Their initial closed-loop prototype was able to schedule tasks to reduce workload based on activity detected in a specific region of the brain.
Since the goal of the core program is to develop these closed-loop systems, this achievement is a major advance for my program.
In their phase 2 SBIR work, NovaSol will continue to improve their sensor design - making lighter, portable and wireless systems for the operational setting.

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Small businesses have provided my programs with immense value, and the SBIR program has been crucial for that success.

I would encourage all of the small business owners in the audience to continue the great work that you are doing.
For those who are not associated with a small business, you should be aware of the fact that there are a lot of small businesses with technical expertise that can provide the vital innovation that can be the engine of change.
Not only have these small business bridged many gaps for my programs, but DARPA's small business office itself provides the capability for assembling and maintaining bridges for DARPA.
Thanks, Connie, for your hard work on their behalf, and a special thanks to Dr. Amy Kruse who has worked with me at DARPA to ensure the technical success of these efforts.
I appreciate your attention this afternoon.