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Small Business Innovation Research (SBIR) Success Story

Ladies and Gentlemen, I'd like to take a few minutes of your time today to tell you about a DARPA TTO SBIR "success story".

As some of you may know, DARPA initiated a broadly based program initiative on micro air vehicles in 1996. The goal/purpose of the DARPA Micro Air Vehicle (MAV) Program was to determine whether evolving technologies could be favorably integrated into a mission capable flight system for military surveillance and reconnaissance applications. The DARPA-hard part of the problem was that no dimension on the vehicle could exceed 15 cm (6 inches). There were no other restrictions on the design trade space—and variations of fixed wing, rotary wing and flapping flight concepts have all been explored within the Micro Air Vehicle Program.

My predecessors at DARPA recognized that this was a new design paradigm, and that innovative and capable people were distributed through out the industry - at the universities—and especially within the small business community—and they cast a wide net in their solicitations.

One of respondents to the original MAV SBIR solicitation was AeroVironment Incorporated. Their efforts in technology development and technology maturation, their efforts in achieving significant mission range and endurance, their efforts in guidance and control and instrumentation, and their entrepreneurial success in convincing the military to consider MAVs are the success story I want to share with you today.

As shown in this first graphic, work began in 1996, progressed through a 6 month Phase I, and followed on to a 2 year Phase II effort. Because of the success of the effort, the MAV Program added funding to the limited availability of the SBIR funding. Funding for the whole effort was less than $2 million.

Figure 2 shows the first flight-test article, which was named the "Black Widow." This very small fixed wing vehicle had a circular platform. It was very light, weighing only 50 grams. It was powered by an electric motor and its maximum flight speed was only 20 meters/second. However, it included an extremely efficient (>70%) lightweight (110 mg) propeller designed in-house at AeroVironment. AeroVironment now has a commercial propellers design business as a result of this activity.

The next graphic shows the evolution of the "Black Widow " platform now exhibiting both increased wing surface area and wing loading (still within the 6 inch limitation) with maximum flight speeds of 40 miles per hour; further improvements in propeller efficiency increased to a dramatic 82%; and 22 minutes in flight duration, using a "heads down" flight control through an on-board color video camera.

The Black Widow airframe and propulsion system ultimately evolved to the performance and capabilities shown in Figure 4. Flight endurance reached 30 minutes, straight line range was 17 kilometers and cruise airspeeds was between 25 to 35 mph. The control system was capable of "autohold" for heading, altitude and airspeed. The communications range was limited to 1.8 km, but I will come back to this point later.

AeroVironment recognized that there was no design precedent for airplanes at this scale size and these very low Reynolds numbers. So they incorporated a multi-discipline optimization (MDO) design approach at the outset of their effort. The next graphic shows the elements included in the optimization of each evolutionary vehicle. Through additions of flight data, incremental improvements in technologies, and ground testing, each vehicle was improved and optimized using their genetic algorithm optimizer.

The anatomy of the final vehicle (which was shown previously in slide 4) is shown in this next graphic. Noting that 49% of the total weight is in the primary batteries, I would draw your attention to the necessary and numerous items included in and distributed within this configuration.

However, a functional military micro AV is much more than just an airframe and power plant. And as a part of its development plan AeroVironment also recognized and addressed most of the "systems" issues and

operational requirements. Since the MAV is envisioned as a reconnaissance and surveillance system for the foot soldier operating in the field, it must be immediately available and useful to him. Simplicity, convenience and size are all of concern to the foot soldier who must carry everything that he needs.

A foot soldier in the field has many things that he must do however; none of them include flying the MAV and taking/recording data. Therefore, AeroVironment developed a light weight transportable Universal Ground Control Unit Aero which is illustrated in this next graphic. This graphic shows the GCU in a one man carrying case, the erection of the simple antenna, and the control unit itself, which is about the size of a laptop computer. Superimposed on the colored daylight readable video image, down-linked from the vehicle, is the important information for the soldier including magnetic heading, altitude, airspeed and the health of the MAV.

Over the course of four years AeroVironment has followed a technology development path shown in this graphic. They progressed from a vehicle that flew for only 2 minutes with no payload to a vehicle that could fly 30 minutes, to an altitude of 769, and transmit color video to a base station 1.8 km away. AeroVironment also recognized that reliable and repeatable launch was necessary for the operational success of the MAV. The cassette launcher is shown on this next graphic. This launcher is very rugged, about the size of a cigar box, weighs 2 lbs. and is expendable. The MAV is installed inside the launcher for transportation and protection. A quick connection to the GCU, orientation of the launcher to a 15-degree elevation, and the press of a button results in pneumatic powered launch and an automatic power on/throttle up for climb out to altitude.

When the military suggested that 1.8 km communications range was too short for effective operations, AeroVironment paired the MAV with their higher flying "Pointer" UAV to accomplish a non-line-of-sight relay system for video relays. As shown on this next graphic, the Black Widow can transmit up to the long endurance GPS controlled loitering " Pointer" and back down to the GCU providing coverage to 20 km using different frequencies. Inclusion of the relay provides reconnaissance and surveillance benefits in both urban and very rugged mountainous terrain.

Until initiation of the DARPA MAV Program in 1996, the U.S. Military Services had never considered micro AVs for field operations. In order to familiarize the services with the potential of MAVs and to learn from field operations, AeroVironment deployed their vehicles to various training exercises. In this picture, MG Newbold is shown at Camp Pendleton inspecting an early version of the Black Widow prior to its demonstration flights. Shown in this next picture is LtGen Knutson holding the “Pointer" vehicle prior to demonstration of the communications "relay" demonstrations.

Because of their strong commitment to maturation of functional and practical MAV concepts, AeroVironment has also been able to conduct several related and technically significant activities that I'd like to mention. When the question arose as to whether stereo images were desirable, AeroVironment explored this problem. As shown in this graphic after several tests activities, AeroVironment was able to demonstrate color stereo images from a 6 foot span airborne platform with 2 high resolution CCD cameras spaced 24 inches apart.

When a question arose concerning the problem of transition from hover to wing-borne forward flight for small-scale vehicles, AeroVironment was able to build and fly their Hoverfly VTOL MAV vehicle within seven weeks. As shown in this graphic, this 180 g vehicle was stabilized in all three axes. Hover endurance with a fixed pitch propeller was 7.3 minutes and cruise endurance was 13.2 minutes.

From this MAV base of experience along with continuous SBIR support from DARPA, AeroVironment has established a business base for small vehicle design. They are the preeminent organization in this field and through their innovative approach have gone on to work in flapping flight concepts, and as subcontractors to the current MAV and OAV contractors. DARPA can and does support innovative SBIR organizations. SBIR organizations have the potential and entrepreneurial skills necessary to excel in this high-risk business environment.

Thank you.