Seed Of An Idea

Nano Air Vehicle grows from ingenuity, collaboration

Brian Boesch, left, chief technology officer at Advanced Technology Laboratories (ATL), and Steve Jameson, ATL principal investigator for the Nano Air Vehicle (NAV), display a scale plastic model of the NAV. The model closely approximates the size and shape of the NAV, but it does not show actual details.

As a kid growing up in the Midwest, Ned Allen was struck one day by the aerodynamic elegance of a maple tree seed. The single-wing rotating design of the seed pod captured the imagination of the youngster who built model airplanes as a hobby and would grow up to be an aeronautical engineer.

"I would think about that maple seed from time to time, but there was never an opportunity to really do anything thing with it," says Allen, who works for Lockheed Martin Advanced Development Programs (Skunk Works). "Then along came this DARPA program."

The Defense Advanced Research Projects Agency asked for ideas for a nano air vehicle (NAV), a tiny remote-controlled aircraft to gather intelligence on the urban battlefield and send it back to the troops who need it. Allen attended a DARPA industry day about the concept, and the more he heard the more excited he got.

"It all came together," he says. "As I heard what they had in mind for this vehicle, I became convinced that the maple seed approach could work."

Eventually, DARPA also became sufficiently convinced of the idea's potential to award Lockheed Martin in April an 18-month contract to design a NAV based on the maple seed concept.

The story of how Allen's idea grew into a $3 million contract — with the potential to grow significantly more — is an example of how individual inspiration combined with the diverse resources of a large corporation can produce revolutionary applications of technology.

Allen advanced his idea through Lockheed Martin Aeronautics Company, of which Advanced Development Programs is a part, and the Aeronautics leadership recognized that the expertise needed to solve some of the NAV's technical challenges resided in the Lockheed Martin Electronic Systems Business Area.

The program was assigned to Lockheed Martin Advanced Technology Laboratories (ATL), which is leading a team that includes, in addition to Advanced Development Programs, Lockheed Martin Advanced Technology Center, the Lockheed Martin-managed Sandia National Laboratories, AeroCraft, ATK Thiokol and the University of Pennsylvania.

The NAV will be about 1.5 inches long and have a maximum takeoff weight of just .35 of an ounce. A chemical rocket enclosed in its one-bladed wing will power the vehicle up to 2,000 yards, carrying a sensor payload module weighing up to .07 of an ounce. Delivered from a hover, the payload module will be interchangeable based on mission requirements. Besides controlling lift and pitch, the wing will also house telemetry and communications, while the hub will house navigation, imaging sensors and battery power.

Engineer Ned Allen's idea becomes reality as a contract is awarded to develop an aerodynamic design based on a maple tree seed.

A model of the Nano Air Vehicle (NAV) is shown with a maple tree seed – the form that inspired the concept and actual aerodynamics of the NAV.

Although aspects of the vehicle will require ingenuity and innovation, the Lockheed Martin design is much less complex than other proposed designs, says ATL's Steve Jameson, principal investigator for Lockheed Martin's NAV program.

"One of the tremendously attractive features of this design is that it is mechanically very simple with very few moving parts compared to most of the other approaches people have taken, which have ranged from a miniature helicopter to something that resembles a flapping insect," Jameson says. "Our design is very robust mechanically and operationally. It'll be much easier for troops to carry and use."

But as is often the case, a simple design belies the complex challenges that have to be overcome to make it so. The single-blade concept has been demonstrated in the past, Jameson notes, but in a larger version. For the NAV, one challenge has been developing a computer model that can accurately predict how such a lightweight vehicle would be impacted by air flow.

"Tools and design processes for airfoils of this size simply don't exist, so we have to create them," Jameson says. "We have a team of people from four different organizations working on that issue."

The other major challenge has been propulsion. Battery power simply could not deliver the amount of energy needed to achieve the required flight duration without being prohibitively heavy.

Here, again, it was Allen's idea that will allow the NAV to overcome the power issue. He had been working on miniature two-stage rocket engines, and he immediately realized when he learned of the NAV opportunity that the engine was the perfect power source to couple with the maple seed platform.

The solid rocket fuel engine will be the focus of the first phase of the program. Most of the gas generated by the tiny engine will provide lift, and a small portion will flow from the tip of the blade to provide direction.

Of course, all of this design elegance won't mean a thing unless the NAV is able to gather intelligence effectively and communicate with its operator. And that's where ATL comes in.

Under the direction of Brian Boesch, chief technology officer at ATL, the laboratories had already been working on systems for linking autonomous vehicles with warfighters. The systems enable the operators to provide guidance and navigation control while receiving information back from the vehicle.

ATL's expertise has been critical in designing the concept for how the NAV will capture data. While the unit is rotating, its miniature video camera will record images throughout the rotation. Sensors will determine how fast the vehicle is spinning, and software will be able to select images from precisely the moment the camera passes the same point, thereby creating a video image of a single scene. The software also will allow the operator to digitally scan an area by simply shifting the scene of interest.

In addition to designing the video capability, ATL is looking at the possibility of equipping the NAV with a laser radar (LADAR) unit that could provide three-dimensional imaging.

The challenge of building the NAV's systems on such a tiny platform will fall to Sandia, which specializes in micro technologies. The Sandia team will perform the microscale fabrication, including the micro electro-mechanical systems valves and the propulsion system.

To think that this futuristic NAV concept has grown from a boy's fascination with maple tree seeds seems a bit fanciful, even to that boy.

"I happened to be up in New York state recently," Allen says. "And the maple seeds were still falling. So I went out and did a little field research just to see if nature had changed the design since the last time I checked." ■

INFO For more information about the Nano Air Vehicle, contact ATL's Steve Jameson at (856) 792-9721.