Air Force SBIR STTR LEGACY SPOTLIGHT
WHERE ARE THEY NOW?
SMALL BUSINESS INNOVATION RESEARCH / SMALL BUSINESS TECHNOLOGY TRANSFER

TOPIC NUMBER:
SB032-033

TOPIC TITLE:
Pyrophoric Fluid Valve (PFV) for Missile Plume Simulation

CONTRACT NUMBER:
FA9101-13-C-0009

SBIR COMPANY NAME:
Active Signal Technologies, Inc.
Linthicum Heights, MD

TECHNICAL PROJECT OFFICE:
Arnold Engineering Development Complex,
Arnold AFB, TN

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Towed Airborne Plume Simulator being tested at AEDC. (Photo by David Housch)

LEAVING A TRACE

MISSILE PLUME SIMULATION FOR DEFENSE TESTING

With the ever-present threat of surface-to-air missiles, many U.S. military jets and helicopters are equipped with infrared or ultraviolet sensors that alert pilots to hostile fire. But those sensor systems are not perfect, leaving American warfighters, and taxpayer investment in the aircraft, still at risk.

The complication lies in a long-standing conundrum: anti-missile defense systems must be tested and proven in realistic environments before being deployed in the field, but testing them against actual missiles is not an option. Instead, testing is done with simulated

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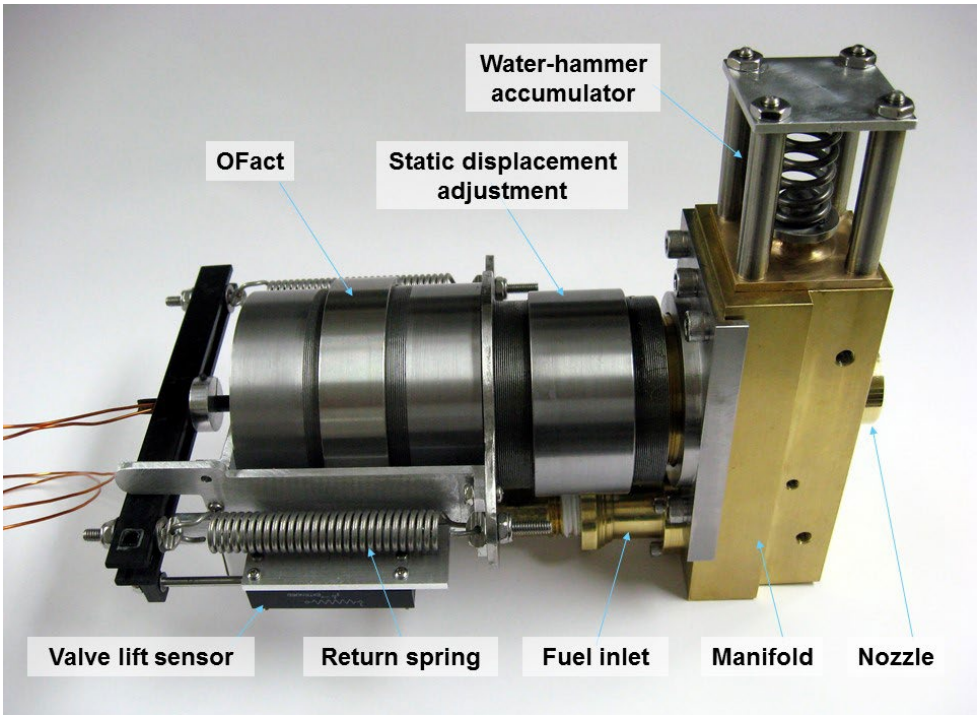
missiles that emit mimic plumes generated by a pyrophoric fluid, which ignites on contact with air. The flow of the pyrophoric fluid is controlled by valves that control the fluid flow to imitate the behavior of real missile plumes. However, the actuators that usually control those valves have limited control bandwidth and begin to overheat and lose power after a few seconds. To improve the effectiveness of simulated missile plume testing, the military needed a completely new kind of fuel valve and actuator system.



Fully-assembled pyrophoric fluid flow valve ready for ground test. (Photo courtesy Active Signal Technologies.)

In 2003, the Air Force's Arnold Engineering Development Complex (AEDC) -- which houses the most advanced flight simulation test facilities in the world -- invited the private sector to help find a solution, with support from the Air Force's Small Business Innovation Research (SBIR) Program. Maryland-based Active Signal Technologies, Inc. (AST or Active Signal) became aware of and accepted the challenge in 2012.

The first piece of the puzzle was the actuator.

"I'd actually been playing with the concept for some time at Active Signal, and we had built a proof-of-principle model," said AST Chief Engineer Dennis Kohlhafer. "AEDC needed something with high force and higher frequency response, in a relatively small size, with a reasonably good operational life span. We thought this new actuator we'd been experimenting with might just work."

The OFact, as Kohlhafer called his new opposing field actuator, not only produced the needed force, it was able to sustain that for over three minutes, compared to the 20-second run time of the old system. This OFact also offered the advantage of a wide dynamic range coupled with high frequency response. Unlike traditional actuators, the OFact could quickly and precisely control and change flow. With that, plume profiles could be tailored from high-, to precisely controlled low-flow rates, to deliver more realistic and accurate conditions for anti-missile defense exercises.

"[Kohlhafer] had a really neat solution for the actuator," said Keith Bridger, co-founder and AST President. "Then we were faced with the nitty-gritty work of designing a valve based on that new actuator, which proved very challenging given the wide dynamic range required."

Challenging, but not impossible. With support from the AEDC SBIR, Kohlhafer and Bridger designed a new plume simulator valve to work with the actuator.

While AST already had the critical technology and concept for the project in place, they credit much of

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their success in implementing the technology to their collaboration with AEDC and other stakeholders, including NASA's Glenn Research Center (GRC).

"This was a great team effort. We got a lot of support from the AEDC staff," Bridger said, "and we consulted quite a bit with the jet fuel people at NASA GRC, who gave us a lot of free advice."

According to Taylor Swanson, an aerospace engineer in the AEDC Analysis and Technology Branch, AST's technology was just what they needed for their Towed Airborne Plume Simulator (TAPS). Developed in conjunction with the Center for Countermeasures, TAPS was designed to test aircraft missile warning systems in operational environments. Swanson considers it a prime example of technology transition through the SBIR program to achieve the Air Force's needs.

"The improved valve/actuator system developed by AST relieved some important limitations of the current system," Swanson said, noting the improved frequency response and run duration. Those advances will allow TAPS to simulate a wider range of missile types and threat engagement scenarios. AEDC intends to incorporate the new valve into operations, and is currently using two versions of the new valve-and-actuator technology in its missile plume simulations.

Moving forward, AST envisions a series of valves with practical applications beyond missile plume simulation. One strong possibility is aircraft controls, said Bridger. "The advantage there," he notes, "is that this type of actuator is very fault-tolerant, which means that if the power fails, the actuator will swing freely instead of jamming in one adverse position."

The technology could also be adapted to metering fuel into jet engines, an application NASA is interested in. "If you can modulate that flow at a certain frequency," Bridger explained, "you can make engines run leaner, with a higher air-to-fuel ratio, which means reduced emissions and increased fuel efficiency." Such a system could be hugely advantageous in commercial aviation. Pushing the benefits even further, the valves could be used to make jet engines quieter, a concern in both military and civilian spheres. The actuator technology also has promising application outside aviation, such as in motion control for robotics. The same quick reaction times that enable the actuator to power fuel valves so precisely can be useful in robotics, which demands quick, precise motions and responses to physical cues.

AST's Bridger credits much of the company's success to SBIR support. "The SBIR/STTR programs are important to the U.S. commercial market because they give small businesses the chance to actually put new technologies to the test," he said, noting that otherwise, potential solutions are just sitting on a piece of paper as somebody's brainchild. "Every young entrepreneurial type—we were young once—has new ideas they want to try, but might not have the opportunity without SBIR funding."