Friendly Eyes, Hostile Skies

An SwRI-developed flight management system adds capability to compact unmanned aircraft system

By Angel Rivera Jr. and Victor Murray

Military, law enforcement and homeland security planners continue to add new missions for unmanned aircraft systems (UAS) as technological sophistication of even the smallest pilotless aircraft has grown. Advances in miniaturization provide autonomous operation capability not only of vehicles the size of a human-carrying aircraft, but also UASs small enough to be transported by a single soldier. Small UASs can carry various video cameras and environmental sensors over a hostile battlefield or a toxic environment without risking the loss of a human pilot.

While large UASs operate from jet runways and fly at high altitudes, their smaller cousins can be carried by a single person and launched from austere environments anywhere to help ground troops see without being seen. The latter type includes Buster, a relatively small UAS provided and designed by Mission Technologies, Inc., a system integration company, for the U.S. Army's Night Vision Laboratory. Its flight hardware, including an autopilot with navigation systems, as well as its ground control station and integrated communication protocols, were developed by SwRI engineers.

The complete Buster system consists of four air vehicles, a single ground control station, a launcher, color cameras and thermal imaging payloads. Buster is light

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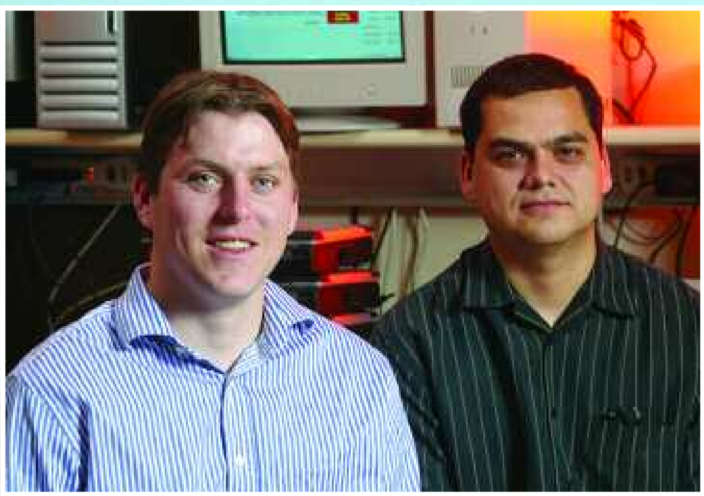

Angel Rivera Jr., right, is a senior research engineer and Victor Murray is an engineer, both in the Aerospace Engineering Department of SwRI's Aerospace Electronics and Information Technology Division. Both specialize in the area of avionics and control systems.

enough to be transported by a single operator. Mission Technologies, Inc. designed Buster for rapid deployment. It can be assembled in the field in minutes and then catapulted into flight from an inclined-rail launcher. The launcher itself extends to 80 inches long but folds in half to ease transport. It uses elastic elements to launch the UAS without need of incendiary devices.

The Buster system has a range of 10 kilometers. Once airborne, its 0.8-horsepower, two-stroke engine has an endurance of up to four hours, or four times that of similar classification electric-powered UASs. This increase in endurance results in fewer take-offs and landings.

The Southwest Research Institute (SwRI)-designed and built onboard flight management system (FMS) is Buster's autopilot and commands the movement of flight control surfaces autonomously while also communicating over a datalink with a ruggedized laptop computer that is part of Buster's ground control system. To save weight and remove the need for a runway, Buster lacks a conventional landing gear; instead, it deploys a parachute over a user-determined location to facilitate recovery, refueling and redeployment. Parachute deployment can be triggered at any time for accurate recovery. Some small UASs are actively controlled by a ground operator via radio signals, but Buster flies autonomously along a mission profile that can be pre-loaded before launch and then dynamically tasked at any time in flight.

Buster s brain

With its autonomous FMS, Buster does not require active piloting via radio control.Instead, the aircraft's own internal electronic instruments sense its attitude and position in the sky and command its three-axis autopilot to move the control surfaces in response. This makes the system easy to use and simplifies training new operators. The SwRI-developed system consists of flight algorithms, servo controls, data link, global positioning satellite (GPS) receiver, and payload control. At only 7 inches long, 4 inches wide and 1.75 inches high, and weighing only 11 ounces including its military-band data link radio, the fuselage-mounted FMS does not place an undue weight burden on Buster. Besides flying the aircraft, the FMS is capable of performing internal pre-flight initialization of all sub-systems, such as GPS and inertial sensors, and it is ready for launch shortly after power is applied. The FMS also provides a platform for

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The rail-launched Buster UAS needs neither wheels nor runways, and its onboard flight management system can be held in one hand.

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Communication and tracking antennas for Buster's ground control system, shown in the laboratory at right, can be easily mounted atop a temporary structure or a vehicle.

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connecting an SwRI-developed hardware-in-the-loop simulator for software acceptance testing and system integration. This simulator is used to develop new software for the UAS. The simulator outputs all inertial data, including sensor and GPS information. It also generates real-time video. This allows SwRI to develop new software without real flights.

The operator uses the ground control system computer, equipped with a motorized antenna that can track the aircraft in flight, to program the GPS waypoints that will determine Buster's course. The system provides active mission planning, target marking, and video display.

The ground control system communicates with the aircraft over a programmable military-band, 225-385 MHz radio data link to send course changes and also receive real-time video and sensor readings both while Buster is in flight and when it has reached its destination. Live video is streamed down a C-band radio link and video images can be stored on the ground computer's hard drive, from which still images can be selected and radioed back to headquarters via the military network. Video feeds from the UAS also can be received at other remote video terminals (RVT) if desired.

The SwRI-developed ground control software contains map displays, caution panels, UAS data, launch steps, and ground device controls such as antenna and payload. Missions can be edited during flight through entry of parameters using a touchscreen or a keyboard. On-screen video display provides integrated map information with live imagery. In-flight mission editing allows the operator to take a closer look at areas of interest in real time. Users can advance the UAS to any waypoint at any time. Recent SwRI software enhancements include convoy over-watch, fuel quantity tracking/auto return, automatic payload camera switching, and multiple innovative search patterns.

Customized software development allows engineers to meet clients' requests for new capabilities by simply adding programming instead of adding weight to the aircraft. When the customer suggests a new

Buster and its launching rail can be folded and carried by an individual. The miniature UAS can be quickly assembled, launched from the rail and later recovered by parachute (see facing page).

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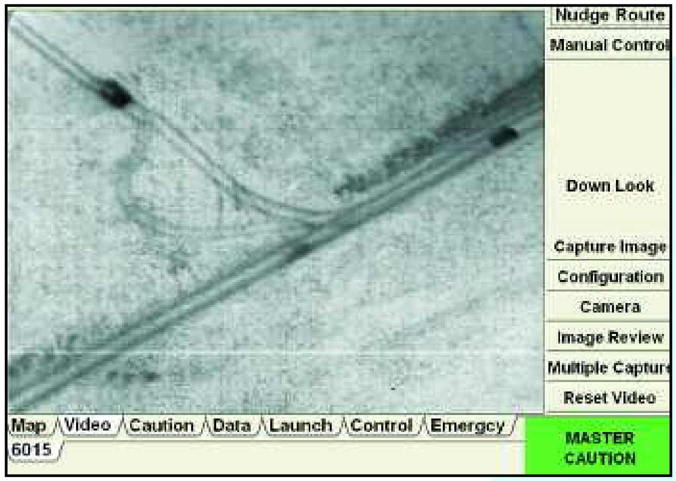
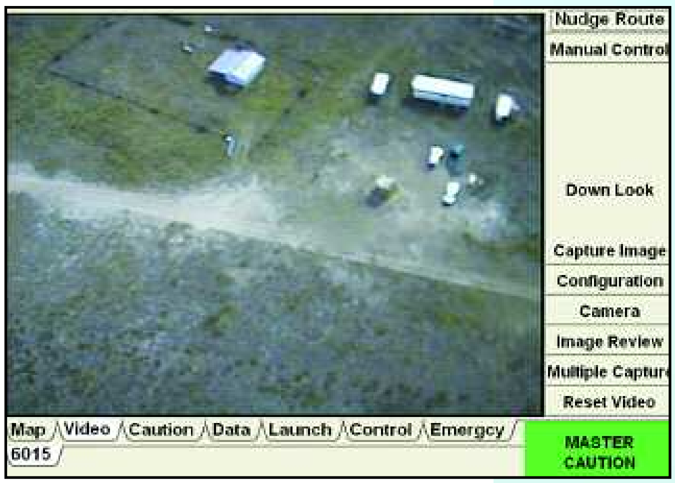
During a mission, Buster can send real-time infrared or video images of objects on the ground while loitering as far away as 10 kilometers from its ground control system.



Images courtesy Mission Technologies, Inc.



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feature, engineers design software to perform the desired function and then program a laboratory simulator to test the new software. Feedback is gathered from the customer on such things as the functionality and interface control of the new feature. Finally, the programming is installed in new aircraft and tested for compatibility with older systems already in the field.

For continuous surveillance missions that require more eyes over the target than a single vehicle can provide, an operator can manage up to three Buster vehicles simultaneously from a single ground control unit using the multiple aircraft control feature. Thus, one Buster can arrive at the target and begin transmitting video while another returns to base and a third is on its way to take its turn. All three can be tracked independently, and the operator can view the video feed or flight data from any of the three vehicles.

Continuing development

Buster's internal systems are an outgrowth of previous SwRI projects involving miniaturized UAS control systems as well as onboard systems for piloted military aircraft. Although work on Buster began about four years ago, its autopilot is the product of more than 10 years of development. This development began in 1994 with an SwRI Internal Research and Development project. Although its airframe is proprietary, Buster employs a number of commercial off-the-shelf components. These include a Mission Technologies modified engine as well as the data link radio, rate gyros, GPS sensors, cameras and the laptop computer for the ground control system. Buster has been successfully demonstrated using the SwRI-developed technology.❖

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Flight management systems for the UAS are assembled, tested in an environmental chamber and prepared for delivery at an SwRI laboratory.