Making Unmanned Aerial Vehicles Smarter

PHOTOS BY GARY MEEK

Recent test demonstrates in-flight ability to autonomously reconfigure low-level control system.

by JOHN TOON

Above: Researchers pose with GTMAX, Georgia Tech's test bed UAV helicopter. They are, left to right, Henrik Christophersen, Dan Schrage, Eric Johnson, George Vachtsevanos and Jeong Hur.

Recent world events have highlighted the utility of unmanned aerial vehicles (UAVs) for both military and civilian applications. In manned aircraft, the pilot is in control, functioning as the integrator of the on-board subsystems and mitigating problems when they occur. With the advent of UAVs, the human integrator capability is lost, which increases the probability of aircraft loss and/or mission failure.

To address this and other related UAV control issues, the Defense Advanced Research Projects Agency (DARPA) and the U.S. Air Force Research Laboratory (AFRL) have launched a major initiative to develop revolutionary new software-enabled control (SEC) systems with applications to intelligent UAVs.

The Boeing Phantom Works and the Georgia Institute of Technology recently demonstrated a key component of the SEC program: an Open Control Platform (OCP) designed to give future UAVs more capable flight control systems. In the demonstration – using the Georgia Tech test bed UAV helicopter, the GTMAX – the Open Control Platform successfully compensated for the simulated in-flight failure of a low-level flight control system by autonomously reconfiguring the SEC software systems.

"This demonstration represents an important step toward the goal of changing the way air vehicle control systems are designed," says Daniel Schrage, a professor of aerospace engineering at Georgia Tech and co-principal investigator for the project with George Vachtsevanos, a Georgia Tech professor of electrical and computer engineering. "The ultimate goal for the SEC program is to create a new paradigm for how advances in information technology will be applied to control systems for complex assets, like air vehicles."

The test demonstrated the ability of the OCP developed by the Boeing-led team to coordinate sensing, flight control algorithms and actuators to allow autonomous, dynamic, low-level flight-control reconfiguration. It was one of a series of technology demonstrations planned for completion during the next two years on the GTMAX and a Boeing experimental platform for the final experimentation. Future experiments are intended to demonstrate extreme UAV performance and coordinated control of multiple vehicles in the execution of a mission scenario.

The SEC program includes 16 organizations divided into SEC technology developers of control-related algorithms and SEC developers of the software infrastructure platform that enables the design and implementation of such advanced control routines.

The Open Control Platform (OCP), a new object-oriented, real-time operating software architecture, has been developed to meet this challenge. The OCP developers are Boeing Phantom Works, Georgia Tech, Honeywell Laboratories and the University of California at Berkeley. The SEC technology developers are California Institute of Technology, Cornell University, Georgia Tech, Massachusetts Institute of Technology, Stanford University, University of Minnesota, Vanderbilt University, Oregon Research Institute, Draper Labs, Northrop-Grumman Corporation and Rockwell Science Center.

Researchers from more than a dozen organizations participating in the SEC program will use the OCP's distributed processing, multi-platform coordination and flexible reconfiguration capabilities to evaluate and demonstrate the breakthrough control technologies they are developing. The OCP also will provide a showcase for advances in future control capabilities, including the ability to coordinate and control multiple UAVs from piloted air vehicles.

The OCP is based on a real-time, distributed object-oriented system architecture known as RT CORBA. While researchers are addressing system fault tolerance in initial demonstrations on the GTMAX system, the OCP represents an advance in open systems able to handle large volumes of data and computations in real time.

"One of the significant challenges is a required update rate of 100 Hz because of the dynamic nature of the helicopter system," Schrage notes. "If you do this with an open, plug-and-play system, it normally means sacrificing performance. Achieving this kind of performance from the open control platform is a real milestone. But we still have a long way to go in realizing the goals of this effort, including ensuring the flight safety of these UAVs."

Beyond the reliability of responding to unexpected system faults, the SEC program will also give the machines more agility, helping them to avoid hostile actions without exceeding critical flight parameters. The SEC team is developing algorithms to anticipate and avoid flight envelope issues that operate through the OCP.

"Current UAVs are not robust enough to deal with all the circumstances they may encounter," Vachtsevanos says. "The SEC program is creating the enabling technologies to make this type of vehicle more reliable, robust and truly autonomous."

This past spring, testing took place on the GTMAX system, a UAV helicopter test bed based on the Yamaha RMAX remotely piloted helicopter that includes a modular, open-systems avionics package along with the OCP. This modular, open-system architecture test bed allows both software-in-the-loop and hardware-in-the-loop testing, in addition to flight testing. Thus, the GTMAX provides a safe and very flexible method for testing advanced control and sensing techniques.

In addition to Schrage and Vachtsevanos, the effort involves Eric Johnson, J.V.R Prasad, Bonnie Heck and Linda Wills of Georgia Tech, along with David Corman, Jim Paunicka, Brian Mendel and Eric Martens of Boeing Phantom Works.

The SEC program plans a number of progressive technology demonstrations over the next two years. While the springtime benchmark demonstration was a major accomplishment, Schrage says, additional demonstrations will go a long way to transferring the SEC technologies, including the OCP, to the UAV community.

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