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Company: Barron Associates Inc.
Website: https://www.barron-associates.com/
POC: Alec Bateman
Phone: 434-973-1215
Address: 11410 Sachem Place, Suite 202
Charlottesville, Va. 22901

Turbulence Recognition Helps UAV Pilots

By Jennifer Reisch

Barron Associates has successfully completed a series of flight tests of its Turbulence Recognition and Decision Support for Unmanned Air Systems (TRADS-UAS) technology, validating the turbulence recognition component of the system.

Unmanned aircraft perform critical missions for the Navy and must manage turbulence to maintain safe operations, minimize maintenance costs, and maximize aircraft availability and lifetime. Pilots of manned aircraft can readily sense and manage turbulence without automation support, but maintaining situational awareness of turbulence is challenging for ground-based unmanned vehicle operators. While turbulence levels may be inferred through indirect clues including airspeed fluctuations, such approaches are unreliable and increase operator workload significantly. The TRADS-UAS system quantifies turbulence levels and provides actionable information to ground-based operators.

Photo courtesy of US Navy

The TRADS-UAS system will enable the MQ-25 to reliably be in a suitable turbulence environment before receiver aircraft arrive, enhancing safety and efficiency of refueling operations.

"I expect you've been in an airplane and you've experienced turbulence bouncing you around. If there's a pilot on the airplane the turbulence is pretty obvious and they will do something to manage it. When you move to unmanned aircraft there is nobody on board and there aren't good systems right now for the unmanned aircraft to duplicate what a pilot can very easily do by feeling the turbulence. There aren't good ways for the people on the ground who are operating an unmanned aircraft to perform that function that an onboard pilot has always performed pretty easily and well. The goal is to provide ground-based pilots with the information they need to do what onboard pilots have always done and done easily," explained Alec Bateman, technical director at Barron Associates.

"A little bit of turbulence is no big deal. If it gets more severe there can be various kinds of problems. At a moderate level it can cause wear and tear on the airplane and increase maintenance requirements or shorten the service life of the aircraft. More severe turbulence can do more immediate damage to the airframe that might require immediate repairs or you could lose control of the aircraft and have a crash or have a structural failure of the aircraft in extreme situations." TRADS-UAS will enhance the safety of UAS operations, reduce maintenance costs and extend aircraft lifetime.

The TRADS-UAS system quantifies turbulence using existing sensors and presents easy to understand turbulence information to human operators or autonomous mission management systems. The display pilots will see with TRADS-UAS will look similar to existing ground station displays and will give a number for turbulence severity; that number would correspond to information pilots are used to seeing in aviation weather forecasting products. There also will be a system of advisories, cautions and warnings, which mean specific things to pilots. “There’s a metric—or a measure of turbulence—called eddy dissipation rates, which is what is shown in a graphical turbulence forecast for aviation. We want to show the pilot the same information so they can relate that to thresholds for dangerous turbulence that are prescribed in those aviation weather products. There’s also an aspect of the system that relates to vehicle limits: If you have a small lightweight vehicle it may not tolerate very much turbulence whereas a big heavy vehicle will tolerate more turbulence. The same atmospheric conditions will affect those vehicles differently,” Bateman said.

An unmanned Boeing MQ-25 T1 Stingray test aircraft, left, refuels a manned F-35 Lightning II. The MQ-25A Stingray will be the world’s first operational carrier-based unmanned aircraft and provide critical aerial refueling and intelligence, surveillance and reconnaissance capabilities that greatly expand the global reach, operational flexibility and lethality of the carrier air wing and carrier strike group.

The display will convey two kinds of data: How much motion is in the atmosphere, which correlates to weather forecasting, and also how much of a problem that amount of energy is for a particular vehicle. “On aircraft there are advisories and cautions and warnings; these things are defined. There are regulations about how information is displayed about those different levels of severity and hazards to aircraft, so we’ll display an advisory, a warning, a caution, which mean specific things to pilots. It will indicate whether it is a minor concern, a serious concern or critical to the survival of the aircraft.

“The first phase of the flight testing for this program was completed on a small four seat general aviation aircraft that we instrumented with sensors comparable to what you’d expect on a medium or large unmanned aircraft. We’re not expecting to add any sensors to unmanned aircraft; this technology uses sensors already in place for flight control purposes. We did a series of tests over several days of flight testing on that aircraft in different turbulence conditions and in different locations to test in different types of turbulence: over flat lands and over mountains and at some range of altitudes. We saw very good correspondence between our independent validation data and what we were measuring with our automated system. Independent validation data included reports from the humans on board as well as ground-based atmospheric sensors—in particular ground based lidar—that could directly measure air movements and directly measure the turbulence. I was on board with a computer getting data in real time and seeing the automated estimates of the system and was able to experience the turbulence in person at the same time. We saw a good correspondence between those different measures so we have independent data validating that our system does what we want it to do," Bateman said.

The successful testing of this technology was a team effort; Barron Associates was supported by Dr. Stephan De Wekker at the University of Virginia, and by the Adaptive Aerospace Group. De Wekker performed atmospheric measurements during the experiments, including operation of the ground-based lidar, to provide independent validation data, and provided atmospheric science expertise to support system development and test planning. The Adaptive Aerospace Group configured and operated the test vehicle and data collection system, which proved to be extremely reliable throughout the test program, Bateman explained. He also noted that John Leonard, the Navy's technical point of contact for this project, has been a great advocate and very supportive of this work.

Next steps will involve tests in different conditions and on different kinds of aircraft. "The National Test Pilot School has a business jet that we are planning to test on next. That will be a similar test procedure but on a bigger heavier aircraft and instead of flying at a few thousand feet will be flying at 30,000 feet. We'll get different drivers of turbulence at those altitudes so hopefully we'll be able to validate that the system can still accurately quantify the turbulence you expect at high altitudes and on a bigger heavier aircraft." The system will also be tested in conjunction with the MQ-25 test program in Pax River where it will be integrated into their ground test monitoring facility and run in real time on the ground for flight test engineers.

Barron Associates is also working with NASA on a similar technology for rotary wing platforms. "The way that it gets applied to rotary wing is significantly different from how it gets applied to fixed wing but there is certainly common technology at the core of it," Bateman said.

As a participant in the Navy STP, Bateman is looking forward to getting the Market Research Analysis Report and going to the Navy FST Sea-Air-Space event. "We are looking forward to that opportunity to network, especially having these test results in hand. It makes a big difference when you can tell someone this has been tested on a real aircraft in a flight and it works."

Barron Associates is a research and development company focused on providing clients with novel solutions to demanding aerospace and health care challenges. These solutions frequently employ intelligent and adaptive technologies to measure, model, predict and control complex systems, resulting in improved performance, safety and efficiency. For more information, visit the company website at https://www.barron-associates.com.

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