Intelligent systems

This was a year of exciting advances for intelligent systems in both aviation and space.

In aviation, DARPA funded Rockwell Collins to design damage tolerant control (DTC) technology to mitigate common UAV failures such as surface damage, airframe damage, and complete engine failure. A series of flight tests were performed with a subscale F/A-18 to showcase key aspects of the DTC technology. DTC's unique, software-based approach to vehicle control has been developed and evolved over the past decade. Flight tests demonstrated completely autonomous flights with loss of ailerons, loss of 60% of a wing and 30% of vertical and horizontal stabilizers, engine-out condition, and 80% wing loss. The combination of all-attitude control and an emergency mission management system provided these UAVs with unprecedented robustness against otherwise catastrophic failures.

Robust adaptive flight control was an area of particular emphasis this year. A collaboration by Wichita State, Kansas State-Salina, Missouri University of Science and Technology, and Hawker Beechcraft demonstrated another adaptive flight control technology for general aviation aircraft. The team, funded by NASA, is advancing model reference adaptive control techniques, investigating adaptation in the presence of aeroelastic modes, and using flight simulation flown by student pilots. Their first flight test on board the Hawker Beechcraft Bonanza AGATE/SATS fly-by-wire testbed showed promising results.

Researchers in the Diagnostic and Prognostic Group at NASA Ames' Intelligent Systems Division, in collaboration with California State Polytechnic University, have designed and built an innovative airborne testbed for conducting research into prognostic health management of electromechanical actuators. Use of such actuators in aerospace vehicles is expected to increase for safety-critical functions. Several experimental flights of the testbed have been conducted aboard USAF C-17 aircraft and Army UH-60 helicopters. During flight tests, the testbed's nominal and fault-injected test actuators mimicked the motion and load profiles that the aircraft's actuators were experiencing, while health management algorithms evaluated conditions in real time.

Southwest Airlines streamlined its operations thanks to NASA technology transfer. This year NASA open-sourced many key data mining algorithms for analysis of output from flight data recorders through DASHlink (dashlink.arc.nasa.gov), a Web 2.0 portal for the world. Using Miner and Orca, two advanced anomaly detection techniques, Southwest was able to uncover operationally significant events that would not be triggered by their existing methods. Orca alone analyzed 7,200 flights from 10,000 ft to touchdown, revealing data quality issues, high roll and pitch events near final approach fix, and hard nose-over prior to landing, leading to everyday changes in the commercial airline's operation.

On the space side, the University of Wyoming pushed the state-of-the-art in evolving intelligent systems that enhance control, stability, and robustness during autonomous assembly of large complex structures in space. The components of an evolving system self-assemble to form new components and are augmented with additional local controls to ensure system stability during assembly. Evolving systems enable modular system design and the reuse of components where scale, complexity, and distance preclude astronaut assistance because of inherent risks and costs. The evolving systems framework provides a scalable, modular architecture to model and analyze subsystem components and connections.

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Enabling astronauts to make better informed decisions, researchers at NASA Johnson and Jet Propulsion Lab unveiled and field tested a new onboard energy management advisory system. It combines an intelligent planner with real-time estimation to provide detailed projections of battery energy across complex activity plans. The onboard planner continually revalidates the activity plan as it is executed and can inform astronauts when projection models indicate that the planned activities will lead to an unsafe state or will jeopardize a contingency plan; the system then suggests recovery options.

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