Digital avionics

by the **AIAA Digital Avionics Technical Committee**

Significant advancements in digital avionics have been demonstrated over the past year in civil aviation, military systems, and space applications. The recent trend in both the civil and military avionics markets has been toward a highly integrated set of avionics systems. The increased focus on systems integration has changed the relationships between avionics suppliers. They now find that they need to work closely together to achieve a fully integrated set of systems. Avionics systems that were once developed and managed as a separate unit are increasingly being managed as a set of highly integrated systems.

The concepts of avionics integration have been around for a few years now, but 2007 has proven to be a significant year for demonstrations of new avionics technologies. On the civil side, the Airbus A380 and Boeing 787 Dreamliner programs have completed noteworthy milestones. On the military side, the Lockheed Martin F-35 Joint Strike Fighter has demonstrated its advancements in integrated systems.

A380 and 787 avionics demonstrations

Airbus A380 avionics integration is accomplished through an integrated modular avionics solution. Several functions are hosted on shared CPIOMs, or core processing input/output modules. The A380 employs seven CPIOMs and one input/output module, all communicating across an ARINC 664 network. The CPIOM hosts 22 integrated software functions that provide services as varied as communications and landing gear extension/retraction.

A student UAV from Cornell University was flown in the annual competition hosted by the Association for Unmanned Vehicle Systems International. Today's students are gearing up to build tomorrow's UAVs.

System integration enables valuable data fusion. Consider the navigation display. The vertical position/weather display is integrated with the navigation display, as are the data from the Aircraft Environment Surveillance System. That system is responsible for integrating the weather radar, a Terrain Awareness Warning System (TAWS), and a Traffic alert Collision Avoidance System (TCAS)/Mode S transponder.

The navigation display is then able to present a vertical profile of the aircraft's flight path that is overlaid with terrain information while also displaying the vertical weather (not just horizontal altitudes) as well as aircraft traffic information. This data fusion provides the pilot with exceptional horizontal and vertical situational awareness that is especially valuable during ascent and descent procedures. This level of integration makes it possible for the weather radar to leverage the terrain database and remove terrain clutter from the radar return.

The A380 has demonstrated its new avionics technologies. At the 2007 Paris Air Show, Airbus announced that the A380 had completed over 1,100 flights and more than 3,700 flight hours.

Boeing 787 avionics integration is also accomplished through the use of integrated modular avionics in a system Boeing calls the Common Core System (CCS). The shared computing modules of the CCS are reported to host as many as 80 avionics and utility functions. Boeing has reported that more than 100 different line replaceable units were able to be eliminated as a result of the systems integration.

As in the A380, the CCS uses the ARINC 664 network for communications. The CCS also integrates signal wiring by replacing traditional dedicated wiring with remote data concentrators, which concentrate analog and digital signals and bridge them onto the network.

The CCS platform hosts noncritical functions like lavatory control alongside flight-critical functions such as cockpit displays. Other systems integrated on the CCS include environmental controls, auxiliary power unit, cabin services, flight controls, health management, fuel, payloads, and propulsion.

The configurable integrated surveillance system, another example of avionics integration on the 787, combines the weather radar, Mode S transponders, TAWS, and TCAS into a single cabinet. The information for this integrated unit is all shown on one pilot display.

Even though the 787 uses many new integrated technologies, pilots should remain comfortable in the cockpit, which looks and feels much like the 777 flight deck. However, the 787 includes glass displays that are 50% larger than in the 777, standard heads-up displays, and dual electronic flight bags. In addition, the flight control system will include the first-ever vertical gust suppression system to automatically make adjustments and smooth the ride when the plane encounters flight turbulence.

Boeing chose the date of 7-8-07 to host a premiere where the first 787 was unveiled. The 787 will complete its maiden flight in 2008.

F-35 avionics demonstration

On the military side of aviation, the F-35 Lightning II made news with its set of integrated avionics solutions. The integration of its advanced sensors and data provides the F-35 pilot with unprecedented situational awareness.

The missions systems incorporate modular open systems architectures. Core to the F-35 systems integration strategy is the integrated core processor (ICP), which hosts many software systems that serve to integrate multiple systems together. A 2-Gbps fiber channel provides the communication bus that connects the ICP with the aircraft's sensors, displays, and other systems.

The ICP collects data from the array of aircraft sensors and fuses them together to form a synergistic data source that feeds aircraft systems and the 20-in. pilot display. Among the integrated systems are an active electronically scanned array radar with a synthetic aperture radar mapping mode, an infrared search and track system for air-to-air and air-to-ground combat, an electrooptical targeting system with a forward-looking infrared imager, a targeting laser, and a laser spot tracker. Thanks to this system integration, the ICP is able to host an automatic target recognition and classification system that can identify specific targets.

The F-35 completed its first flight on December 15, 2007, kicking off a 12,000-hr flight test program. The F-35 cooperative avionics test bed (CATB, aka "CAT-Bird"), built on a Boeing 737, replicates the F-35's avionics suite and is used to develop and test the suite of highly integrated systems. Its first flight was on January 23.

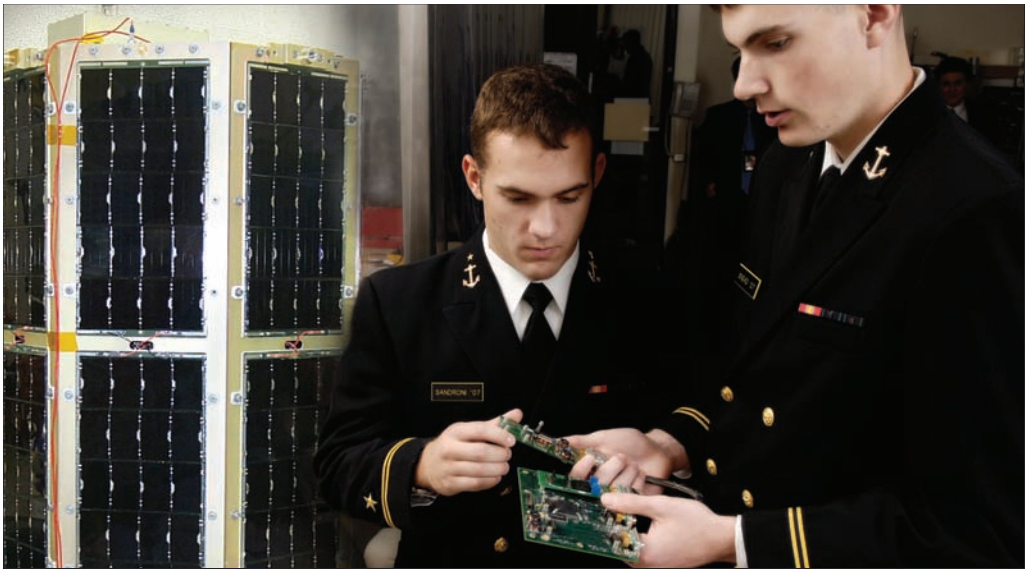
As in the commercial avionics market, the military avionics environment has become very integrated.

Autonomous docking and refueling

DARPA reached a notable milestone this year when it sponsored a successful demonstration of in-orbit autonomous docking and refueling with its Orbital Express satellites. Such an ability could be used to extend the lives of government and commercial spacecraft.

The Orbital Express demonstration consisted of two spacecraft: the Autonomous Space Transport Robotic Operations (ASTRO) servicing spacecraft and the Next Generation Serviceable Satellite (NextSat). The spacecraft were launched together in March 2007. ASTRO demonstrated its ability to approach NextSat, dock with the spacecraft using a robotic arm, and then transfer fuel and hardware. This was an autonomous demonstration that only included limited interaction from the ground.

On June 22, ASTRO completed the first-ever autonomous capture of a satellite by another satellite using a robotic arm. On July 2, ASTRO successfully accomplished the first transfer of liquid fuel between orbiting satellites as well as the first component exchange (functional battery and computer) in space history.



A student satellite was launched with DARPA's Orbital Express. Built by U.S. Naval Academy students, MidSTAR-1 provides an experimental base for students who are working to build our future in space. An onboard NASA experiment includes the first successful use of nano-engineered technology in space.

This success was based upon the autonomous guidance and navigation systems and their associated sensors. The onboard guidance, navigation, and control system relies on an autonomous rendezvous and capture sensor system, which consists of three image sensors that measure the relative angle, range, position, and attitude between two spacecraft. It works without ground control and provides feedback to the chaser spacecraft in real time to support the autonomous operations.

Once reaching the final approach, the advanced video guidance sensor went to work. This laser-based tracking system was used to measure attitude, range, and bearing of the NextSat when in close proximity.

This highly successful demonstration is sure to drive the future of satellite systems.