Innovations in avionics that help flight crews recognize unsafe situations emerged as a common thread of several presentations in the Joint Meeting of the Flight Safety Foundation 61st annual International Air Safety Seminar, International Federation of Airworthiness 38th International Conference and International Air Transport Association. How soon they might be adopted remains unclear, however, while governments and the aviation industry jointly resolve technology-policy issues and finalize regulations to require installation of automatic dependent surveillance-broadcast (ADS-B) avionics; encourage wider use of satellite-based navigation aids such as the global positioning system (GPS); and introduce avionics, automated charting and pilot training to encourage broader implementation of required navigation performance (RNP) area navigation (RNAV) flight operations.

Some of these innovations are prompting the U.S. government, for example, to reassess strategies being applied to difficult operational risks on airport surfaces, much as near-universal use of terrain awareness and warning system (TAWS) equipment already has done for in-flight risks. Scott Dunham, air traffic control investigator in the U.S. National Transportation Safety Board (NTSB) Operational Factors Division, said that both the NTSB and the U.S. Federal Aviation Administration (FAA) envision rapid and significant safety improvements, for

Flight deck upgrades, many via software, could unleash ADS-B, RNP RNAV and GPS on intractable aviation threats.

Repurposing AVIONICS

BY WAYNE ROSENKRANS | FROM HONOLULU

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example, from airlines implementing advanced cockpit moving-map technology as soon as it fully meets industry expectations. "It looks like that is happening pretty quickly," Dunham said.

In recent months, Category A runway incursions, the most serious type, in Fresno, California, and Allentown and Reading, Pennsylvania — small U.S. airports unlikely to install advanced surface movement guidance and control systems (A-SMGCS) — underscored the lifesaving role that upgraded avionics could play for that threat alone. In Reading, a landing Cessna Citation collided with a tractor on a runway, without serious injuries. In the other two incursions, pilots perceived the imminent high-speed collisions and averted them by margins of 10 ft (3 m) and 30 ft (9 m), he said.

Decade-old NTSB recommendations for air traffic controller–centric warnings to pilots quickly are being overtaken by the avionics advances, particularly the cockpit moving map with ownship display — the term for the flight crew's aircraft — and new runway alerting systems, Dunham said. "We are big fans of ADS-B," he said. "The [NTSB] is on record saying we want to see ADS-B In [as well as ADS-B Out capability] … for position data from other aircraft to be available to the pilot in each aircraft [and] a data path into the aircraft that the industry can start using for things like conflict warnings and transmitting conflict data. When ADS-B gets a little more mature, that could become the communication path for traffic exchange with a lot of possibilities. But right now, we don't even have the path, so we need to get that done."

To implement ADS-B as the cornerstone of the Next Generation U.S. air traffic control (ATC) system, the FAA has to address dozens of issues that have cropped up, including cost-benefit objections and even competitive disadvantages raised by some aircraft operators, said Steve Brown, ADS-B co-chairman, FAA Aviation Regulatory Advisory Committee and senior vice president, operations, National Business Aviation Association. "ADS-B is a technology that is well proven — its technical capabilities and operational [safety] benefits are fairly well known and have proven to be very positive," Brown said. "But benefits barely exceed the costs, so one of the things that we have been working on is to strengthen the business case and identify ways for the FAA to provide more benefits at lower cost so that we have a more rapid transition to this technology."

Brown expects ADS-B to make significant contributions to U.S. airline safety. "It certainly helps to increase situational awareness, not only through the precision of the technology [in weather avoidance and surface movement] … but improved displays of aircraft position and [relative] position to other aircraft in the system," he said. "There also are position accuracy and terrain avoidance benefits … increasing separation assurance, and preventing collisions." The committee will continue advising the FAA in early 2009 on issues such as operator security, privacy and tracking with ADS-B technology, and public disclosure of information, he added.

The FAA has proposed a dual-link strategy for the United States that requires aircraft that operate at or above Flight Level 240 (about 24,000 ft) to broadcast data via the 1090 MHz

From top, Brown; Bateman; Henegar; and William R. Voss, FSF president and CEO.

All Photos: Wayne Rosenkrans

extended squitter (1090ES) data link, while aircraft that operate below that flight level would use the 978 MHz universal access transceiver (UAT) data link. "Most of the rest of the world is considering using 1090ES only, a single frequency, but there are some implications for the terrain-alert and collision avoidance system [TCAS] and some safety issues that may require the dual-link strategy [as] the preferred international standard," Brown said. "In very large urban areas — New York, Chicago, Tokyo — we could get to a saturation point, causing the system to degrade to an unacceptable point due to frequency congestion, with the anticipated growth in traffic. There are going to have to be some modifications to TCAS to deal with that saturation and the congestion of all of the radar signals and the ADS-B signals anticipated."

Transforming what originally were single-purpose avionics units into multi-purpose platforms, and/or creating safety-related synergies from discrete avionics units, makes possible additional safety-related capabilities at relatively low cost. "One of the great things that happened last year and early this year was the ability to change to moving-map display [applications in Class 2 electronic flight bags] in the cockpit," said Don Bateman, corporate fellow and chief engineer, flight safety technologies, Honeywell Aerospace. "[The Runway Awareness and Advisory System] was 'bolted on' the runway database that existed already so we would know the latitude and longitude of runway ends, and such things as displaced thresholds, runway widths and altitudes. We married that data with GPS data, and by putting in some aural/voice advisories, announced when pilots are entering a runway, when they are on a runway and so on. This requires no wiring, airlines just drop it into place. Coupling that with the moving map made a great combination."

Ongoing research and development seeks to deliver directly to pilots the automated collision warnings that U.S. air traffic controllers increasingly will receive as enhanced versions of airport surface detection equipment, model X (ASDE-X) are installed at more airports; this has been implemented outside the United States as an enhancement to A-SMGCS, Level 2.

"In spring 2008, we supplied two airplanes and modified their TCAS units so they would have [synthesized] voices that could talk to the pilots when the aircraft were converging," Bateman said. "At Boston Logan International Airport, we had instances where ATC was controlling opposite [traffic on] converging runways. We linked the ASDE-X aural warnings directly to each pilot to take care of the delay time that occurs between the ASDE-X warning to the controller and relaying it to a pilot."

In related research and development, using a simple two-frequency radio receiver, Bateman's engineers this year studied data currently being transmitted during high-volume airline operations at London Heathrow Airport. They used avionics simulators in a nearby hotel room for real-time display of aircraft takeoffs, landings and taxiing on digital maps by processing the data received from ADS-B Out avionics aboard large commercial jets. "We are not doing enough with this capability — and this is not something unique to my company, a lot of companies make equipment [that could exploit ADS-B data]," he said. "We need to get the ADS-B standards put to bed in a hurry."

Researchers also have merged new and existing avionics functions by creating software that places a "virtual ruled box" around a runway and adds TCAS algorithms that annunciate to the pilot — by aural alert and pictorially on the cockpit moving-map display — that a runway is occupied, except when the conflicting aircraft is exiting from this box.

With designers anticipating that GPS or equivalent position data will become common on airliners, other prototype software upgrades enable automatic monitoring of whether flight crews are conducting a stabilized approach per their airline's standard operating procedures, providing advance advisories of a deep landing or long landing, and capability to annunciate a go-around recommendation if the airline wants it. A crew that adheres to stabilized approach criteria gets no alerts from this stabilized approach advisory system.

"This software is dropped into existing hardware, such as an enhanced ground proximity warning system," Bateman said. "In the United States alone, however, we have 2,000 large airplanes without GPS. A lot of these technologies, such as moving map, require a GPS processing engine, which operators also need for ADS-B."

Other safety advantages in the context of satellite-based navigation and 21st century ATC services will emerge from avionics designed for RNP RNAV for approaches and departures that previously were not geographically, technologically or economically feasible, said Marc Henegar, director of RNP/RNAV initiatives, Air Line Pilots Association, International and a former technical pilot for Alaska Airlines. Nondirectional beacon and VHF omnidirectional range approaches are rendered obsolete when an airline implements an RNP RNAV approach offering a stabilized path with lateral and vertical guidance to the runway, including a precise missed approach path.

The level of precision alone strongly mitigates the risk of controlled flight into terrain (CFIT) in all phases of flight, Henegar said. "Instead of worrying about a visual procedure into a high-terrain environment, you have an RNP track that you can follow all the way to the airport," he said. This also helps pilots deal with frequent risk tradeoffs between conducting a nonprecision approach that adds significant time/distance to an arrival and conducting a visual approach with responsibility for terrain avoidance that could deteriorate with reduced visibility.

"We are getting to a tipping point where we have critical mass for RNP," Henegar said. "Using RNP RNAV procedures, each airplane takes less space and flies shorter, more efficient tracks and idle path descents; this allows less-restricted flying. When you use a vertical navigation path … you've got speed guidance [and] a repeatable lateral, vertical and time-based track."

Alaska Airlines has used RNP RNAV avionics on Boeing 737 airplanes for about 12 years for increased airport access during adverse weather and "tens of thousands of pounds" of extra passenger/cargo lift, Henegar said. Increased access to Juneau, for example, resulted from discontinuing use of a Runway 8 approach that has a minimum descent altitude of 3,000 ft and visibility of 4.0 mi (6.4 km), replacing it with an RNP RNAV approach providing minimums of 700 ft and 1.0 mi (1.6 km).

"On Runway 26, down a windy fjord, there was no approach; now there's an approach that goes down to 337 ft and 1.0 mi," he said. "[RNP RNAV] makes the difference between doing a night circling approach in a driving rainstorm to a 6,000-ft [1,829-m] runway that is wet, slick and with no overrun protection while providing my own glide path information, and simply following a flight director with an autopilot down to the runway in a controlled environment." Six other U.S. airlines are adopting some of the FAA's public RNP SAAAR (special aircraft and aircrew authorization required) approach procedures or internally developed special RNP approach procedures. Three non-U.S airlines are conducting special RNP approaches and departures, he said.

Entering 2009, avionics upgrades designed to target the persistent risks of CFIT, runway incursions and excursions, and runway collisions seem timely following a year when only loss of control displaced CFIT as the accident data category with the most fatalities in large commercial jets worldwide. James M. Burin, FSF director of technical programs, citing preliminary tallies of the number of accidents from Jan. 1 to Oct. 24, said, "We have already had 16 major accidents in 2008 in Eastern-built and Western-built commercial jets. Only six of these have been approach and landing accidents; this is quite unusual, a very low number, which is good. There have been two CFIT accidents, and five loss of control accidents. Four of these accidents have been runway excursions." Seven of 27 major accidents involving Eastern-built and Western-built commercial turboprop airplanes also have been CFIT accidents, yet a CFIT accident has yet to involve any commercial jet or turboprop equipped with properly updated and operating TAWS on the flight deck, he said.