ADS-B

Five of UPS Airlines' 107 Boeing 757s and 767s currently have second-generation ADS-B avionics.

UPS Airlines takes aim at runway incursions and unstabilized approaches.

BY WAYNE ROSENKRANS

The U.S. Federal Aviation Administration's (FAA's) selection of ITT Corp. to lead a team of companies to provide ground station services for the Next Generation Air Transportation System (NextGen)[1] reflects a growing trend in several countries around the world to base future air traffic control (ATC) on automatic dependent surveillance–broadcast (ADS-B) technology.

The safety benefits expected from NextGen receive less attention than traffic capacity and funding issues, but they could include less risk of ground collisions, unstabilized approaches, wake turbulence encounters, complex low-altitude vectoring and altitude deviations. And these benefits could arrive sooner than the FAA's 2010–2013 time frame for completion of the ground infrastructure. Safety benefits might accelerate if U.S. airlines upgrade their fleets before the FAA's proposed requirements for "ADS-B out" [2,3] take effect in January 2020, according to UPS Airlines, a U.S. airline with 11 years of experience with ADS-B.

Capt. Bob Hilb, advanced flight systems manager, UPS Airlines, believes that reducing the risk of runway incursions could emerge as the greatest safety benefit of ADS-B. "The U.S. Commercial Aviation Safety Team found that none of the mitigating strategies it studied were more than 50 percent effective, and many of them were a lot less effective — except ADS-B enabling traffic displayed on surface moving maps in the cockpit," Hilb said.

UPS Airlines already has experienced a situation in which a crew was able to see on its cockpit display of traffic information (CDTI) that another aircraft was landing on the same runway, Hilb said. The cause was a combination of controller and crew errors. "Our crew saved the situation by being able to see that an aircraft was on final behind them and alerting ATC," Hilb said. "Many times, when aircraft are on parallel runways — one a takeoff runway and the other a landing runway — the traffic-alert and collision avoidance system (TCAS) is not accurate enough to know whether another aircraft actually is landing on its landing runway or on the parallel

departure runway. After installing ADS-B, the on-board system becomes accurate enough to tell the difference."

The FAA's airport surface detection equipment, model X, (ASDE-X) complements ADS-B avionics by immediately generating a complete traffic display on cockpit moving maps. "ASDE-X is fairly accurate," Hilb said. "For example, when ASDE-X upgrades are completed in late 2008 at Louisville [Kentucky, U.S.], UPS Airlines crews not only will be able to see on their cockpit displays the positions and movements of all company aircraft equipped with ADS-B out during their daily rush period from 2300 to 0130, but all other aircraft landing/taxiing at Louisville with an operating transponder."

Another safety benefit will be new means of reducing wake turbulence encounters near Louisville. "If you use time-based separation of arriving aircraft every time, you end up with a very predictable system and you can do more to alleviate the wake turbulence threat," Hilb said. "Once we have determined where everybody is and when they are coming in to land, we can schedule arrivals an hour or more in advance. Spacing can be assigned and calculated way before aircraft get into the terminal area."

Elimination of low-altitude vectoring in the arrival procedures, made possible by ADS-B, also generates safety benefits. The main benefit would be a reduction in unstabilized approaches, Hilb said. "Low-altitude vectoring is a high-workload situation, and crews tend to make more mistakes," he said.

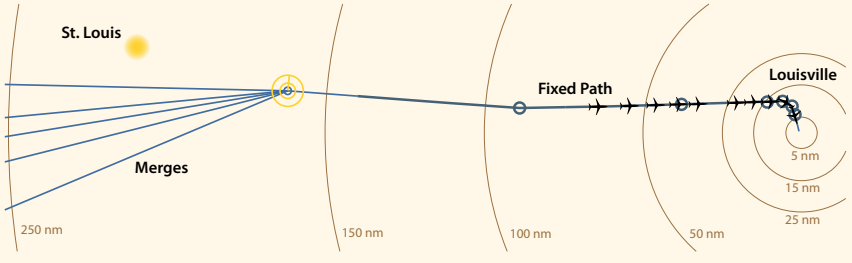
Continuous Descent Arrivals

Airlines may struggle making a safety case for installing ADS-B equipment, but the avionics also offer operational benefits. For UPS Airlines, one focus has been harnessing the technology to address the unpredictability of arrivals of company aircraft to its hub airport in Louisville. "What we are trying to do is change the way the current ATC system handles these arrivals, which makes the peaks and valleys in the operation very random," he said. "Our crews get a lot of long vectors at low altitude because of the uneven flows that come in." In March 2007, the airline told a subcommittee of the U.S. Congress that "our flights end up driving around at low, highly inefficient altitudes while waiting their turn for landing — sometimes flying 60 to 70 nm [11 to 130 km] to travel the last 40 nm [74 km] of flight."

The airline is on the verge of introducing procedures and training for precisely scheduling arrivals with time-based spacing rather than distance-based spacing, enabling a high degree of predictability about when each aircraft will touch down, maximizing airspace utilization. Under the pending ATC procedure (Figure 1) for Louisville, a NextGen required navigation performance (RNP) area navigation (RNAV) continuous descent arrival, each aircraft follows the same fixed flight path from Flight Level 350 (about 35,000 ft) to the runway using a near flight-idle power setting without intermediate level-offs or any low-altitude vectoring by ATC. The airline has obtained FAA certification for this procedure, but operations have not begun pending final approval from the FAA.

"We have built this arrival on RNP RNAV navigation, and the difference in the way we do it currently versus the way we will do it in a scheduled system

RNP RNAV Continuous Descent Arrival



RNP = required navigation performance RNAV = area navigation nm = nautical mile

Source: UPS Airlines

Figure 1

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The cockpit display of traffic information shows the own ship as a blue triangle merged behind the UPS2 airplane and actively controlling its speed to maintain proper in-trail spacing.

with ADS-B is that we had to 'build the arrival to the runway,'" Hilb said. "We created one fixed path to the runway but we could have multiple merges with aircraft coming onto the constant/calculated path from different directions. About 8 or 10 nm [15 or 19 km] out, we would bring aircraft streams together into one stream to the runway." With future data communication, dynamic alterations of the fixed path would be able to adjust the procedure for thunderstorms.

Part of the concept of the procedure is for each aircraft crew joining the fixed path, or already on the fixed path, to maintain specified spacing ahead of them for the aircraft sequenced to merge onto the path from another direction. "Whenever a crew gets within ADS-B range, which is about 100 nm (185 km), they start following the aircraft merging from the other direction," Hilb said. "We build the schedule, then we turn the spacing over to the aircraft crews."

Unstabilized Approaches Vanish

During flight testing of continuous descent arrivals, the strict scripting removed the ATC variability that leaves crews guessing how they will fit into the traffic flow. "Continuous descent arrivals are so scripted that every crew has to put flaps out and gear down at the same point," Hilb said. "It is totally predictable, and the whole procedure also is designed so that crews have sufficient energy management that they do not get caught behind the power curve — or ahead of it if they have too much energy. We now get the aircraft spacing we need to an accuracy within a couple of seconds. We also found that unstabilized approaches disappeared; we did not see any during our tests."

In place of conventional vectoring, flight crews on a continuous descent arrival slow down or speed up along the fixed path with automation and guidance generated by the ADS-B avionics.

"It is hard to measure the pilots' workload, but we think it will be lower because it is totally predictable," Hilb said. "ADS-B gives them an extra speed display to monitor but typically from 35,000 feet there are less than 15 speed changes in a half hour, one speed change every two minutes. We also have done away with a lot of the ATC-pilot voice communication about level-offs." Level-offs have been associated with deviations from assigned altitudes, so that risk is reduced simply by eliminating level-offs, he said.

Smarter Visual Approaches

ADS-B technology also will play a role in visual approaches by UPS Airlines crews using CDTI assisted visual separation upon approval by the FAA. In this procedure, if a crew loses sight of the aircraft in front of them in visual meteorological conditions (VMC) because of haze, sun glare or ground lights at night, for example, they will be able to continue the approach using the CDTI.

"If a crew is arriving at an airport on a visual approach, the ADS-B information allows them to do a better visual approach because they can electronically couple with the aircraft they are following, and know its call sign, airspeed and closure rate, and anticipate what its crew will be doing," Hilb said. In the long term, the airline will have to demonstrate to the FAA that spacing based on ADS-B is precise and predictable enough on every flight in VMC and instrument meteorological conditions for the regulator to change the rules to shift responsibility for separation and wake turbulence avoidance from ATC to the crew of the aircraft following.

Upgrade Paths to ADS-B

New-generation large commercial jets such as the Airbus A380 and Boeing 787 can be

equipped with ADS-B fully integrated into their flight decks. The feasibility and cost of retrofitting ADS-B avionics in older aircraft depend primarily on the aircraft generation, Hilb said. "For commercial aviation, ADS-B really can be an upgrade to current equipment," he said.

UPS Airlines considers its latest retrofitting solution for the 757s and 767s simple. The airline basically upgraded Mode S transponder software, added another processor to the existing TCAS hardware and added CDTIs.

With new software, nearly any Mode S transponder delivered in the last 10 to 15 years can be modified to continuously broadcast ADS-B out messages; some aircraft already have the software and only require the latest update. Standard TCAS hardware incorporates a radio operating on the 1090 MHz frequency that can be converted to receive the ADS-B out datalink signal. Aviation Communication and Surveillance Systems (ACSS), a company partnering with the airline in ADS-B system development, added a second processor to the existing TCAS box. "We then call that box a 'surveillance processor' because it not only receives TCAS signals but has all the ADS-B receiver functionality," Hilb said.

Next, decisions about CDTIs have to be made. "The airline can get a standalone display or upgrade the avionics on board aircraft so that ADS-B is integrated into the glass displays it already has," Hilb said. "Trying to do such an integration on a retrofit basis would be very expensive, however. We needed CDTIs and capability for future controller-pilot datalink communication. The Boeing Class 3 electronic flight bag (EFB) gave us multiple applications on one system, so that is where our cockpit display of traffic information is, and where we plan to have the data communication and digital terminal charts and aircraft document functionality."

Operational plans to use RNP RNAV continuous descent arrivals and CDTI assisted visual separation require more display equipment than CDTIs, however. "Because the EFB is not in the pilots' forward field of view — it is off to the side — we had to place the speed commands and distance information in their forward field of view while they are using the ACSS SafeRoute merging and spacing application on the EFB," Hilb said. "We installed a small, inexpensive display in front of the crew that shows the distance to the aircraft in front of them and the speed that they need to maintain. When the crew switches to the assisted visual separation, the display again gives distance to the aircraft in front of them but also gives them closure rate in knots and a plus sign if their own aircraft is gaining or a minus sign if the two aircraft are moving apart. The most expensive part of retrofitting is equipping an aircraft with these displays."

Some specialists argue that wide adoption of ADS-B avionics will be essential to reap the full benefits of this technology. "Everybody — or at least a sufficient percentage — has to be equipped to make the benefits possible," Hilb said. But if just one airline equips its fleet with ADS-B avionics and then introduces RNP RNAV continuous descent arrivals, its competitors would be disadvantaged because "all would be left flying the low-altitude vectors and spending a lot more time and fuel getting into the airport," he said.

Hesitation about equipping aircraft with ADS-B too soon is understandable, he said. "ADS-B is brand new technology, and until the industry actually has been flying it for awhile, the majority of people are in wait-and-see mode; they are not going to invest any money until they see ADS-B completely working — until we demonstrate that the technology is more than 'just a middle-of-the-night system for UPS,'" Hilb said. "Until airlines know the benefits are real and actually see ADS-B working, they will not step up to acquire the avionics. But the cost is coming down to less than what we paid for ADS-B, and there will be more competition."

ADS-B avionics, meanwhile, are becoming more mature and robust after years of refinements by international standards committees. "UPS Airlines has found that with ADS-B, everything is now performing pretty close to the way it should be," Hilb said. ●

Notes

1. U.S. Joint Planning and Development Office. *Operational Concept for the Next Generation Air Transportation System (NextGen).* Version 2.0. June 13, 2007. When its selection was announced Aug. 30, 2007, ITT Corp. said that a team of contract companies "will deploy a nationwide air traffic control surveillance network consisting of field radio sites, data processing centers, network operations centers and equipment to enable delivery of surveillance data to air traffic control facilities." ADS-B development and implementation for ATC currently are under way in Australia, Canada, a number of European countries and India.
2. FAA, U.S. Department of Transportation. "Automatic Dependent Surveillance-Broadcast (ADS-B) Out Performance Requirements to Support Air Traffic Control (ATC) Service." Notice of proposed rulemaking. Oct. 1, 2007.
3. An aircraft equipped for "ADS-B out" transmits the aircraft's position, velocity and other specific message elements once per second. An aircraft equipped for "ADS-B in" can receive these message elements.