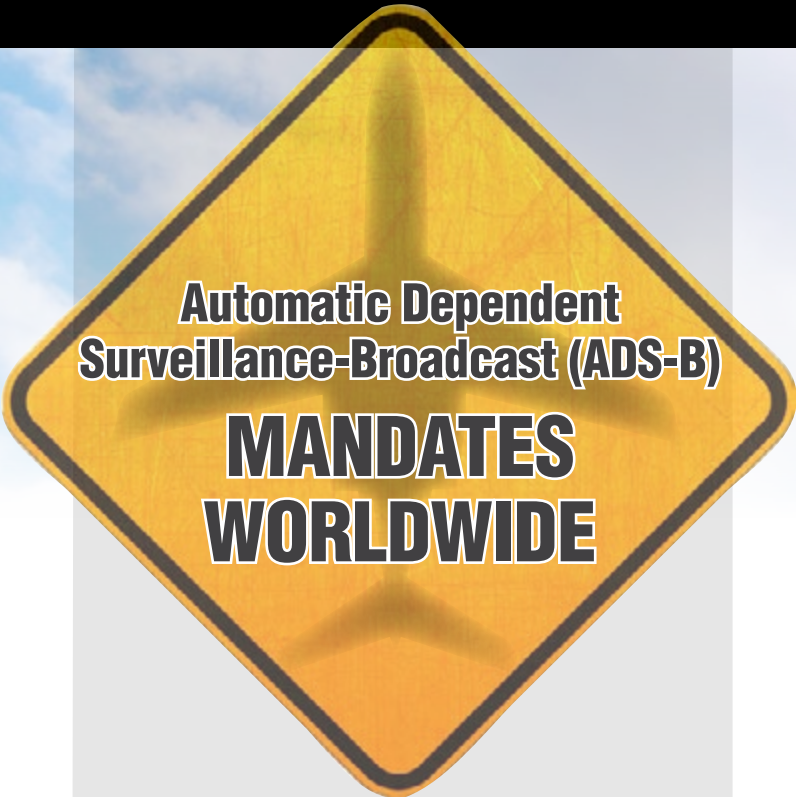




Automatic Dependent Surveillance-Broadcast (ADS-B) MANDATES WORLDWIDE

What, Why, When and How

There are at least 165,000 aircraft in the U.S. alone (and more than 300,000 worldwide) that must comply with new mandates to equip with ADS-B. At least 20,000 of those aircraft are equipped with Honeywell or Bendix/King avionics, according to Scott Miller, director, TCAS and transponder product line for Honeywell.

“Honeywell wants its customers to know what their ADS-B options are,” said Miller. “We are ready to help them equip, whether they operate under 14 CFR Part 23 or Part 25, domestically or internationally. With our MRO partners we can provide solutions that work today and tomorrow.”

Curious about ADS-B? Are you ready to equip, but not sure how, or when? This white paper can help answer your questions.

What is ADS-B? Where did it come from?

From the moment aircraft began sharing the skies, separation has been an issue. “See-and-Avoid” was the key to keeping aircraft apart in visual conditions. But when pilots began to fly regularly in conditions that precluded seeing anything out the windshield things got more complicated.

Pilots reported their position as accurately as they knew it to air traffic control, which plotted those positions so that they could envision where each aircraft was in relation to the others, and provide directional and altitude control to keep aircraft separated. When it worked (and it did work most of the time) it was a little miracle.

Radar was a significant improvement. Secondary surveillance radar (SSR) grew out of the military’s Identify-Friend-or-Foe (IFF) system. It relied on one key piece of airborne technology: the transponder. Constantly circling SSR ground-based antennas interrogate airborne transponders. The response from the aircraft’s transponder is received by the antennas, which send it to air traffic controller screens, where the “blip” is mapped, allowing controllers to “see” the aircraft. If you could keep the “blips” apart you could keep airplanes and the people in them safe.

As airborne transponder technology and ground-based SSR advanced, the accuracy and amount of information available to air traffic control did as well. Mode A brought the ability to electronically identify specific aircraft through a 4096 code assigned by the controller, and Mode C added altitude information. Mode S further improved the controller’s ability to identify specific aircraft through additional information included in the interrogation reply as well as providing the controller the capability to interrogate specific aircraft (rather than a general “all call” interrogation).

What ADS-B IN/OUT Can Do

Combined, TIS-B and ADS-R provide ADS-B IN-equipped aircraft with a more complete airspace and airport surface traffic picture. ADS-R delivers traffic data within a 15-nm radius, 5,000 feet above or below a receiving aircraft’s position. TIS-B provides traffic data within a 15-nm radius, 3,500 feet above or below the aircraft. But ADS-B can do much more. Here are just four future applications:

- ▶ In-Trail Procedure (ITP) using ADS-B IN allows aircraft to fly at better altitudes in oceanic airspace, where there is no radar. ITP allows for reduced separation between aircraft transiting from one altitude to another.
- ▶ Flight Deck Interval Management (FIM) enables more precise spacing between aircraft. When ATC clears the FIM aircraft to follow an ADS-B OUT aircraft, the avionics offer the FIM crew speed guidance, allowing them to maintain precise spacing from the aircraft in front of them.
- ▶ Traffic Situational Awareness with Alerts (TSAA) is an ADS-B IN application for aircraft that do not have TCAS. Using ADS-B OUT information TSAA will aurally alert the pilot of a potential collision. With TSAA, aircraft will be able to land on closely spaced runways in almost all weather conditions.
- ▶ Advanced Interval Management (IM) operations will allow extremely precise spacing and merging of aircraft from various directions and flight paths with minimal ATC involvement.

Traffic congestion around high-use airports necessitated the development of both primary and secondary airport surveillance radar, which can surveil aircraft up to 60 miles from its antenna. Primary airport surveillance radar can also measure six levels of rainfall intensity, providing ATC with a window into the weather conditions being experienced by aircraft under its control.

All of these ground-based systems come with significant price tags for maintenance and upkeep.

The introduction of on-board Traffic Collision Avoidance Systems (TCAS), which are able to “listen in” on other aircraft’s transponder transmissions, began the process of aircraft providing self-separation electronically. Initially introduced for separating airline traffic (along with its little brother Traffic Advisory Systems [TAS]), it has found its way into all segments of aircraft. Effectively, TCAS is a safety system that alerts pilots when safe separation, managed by controllers or visually, is at risk.

In the 1990s the regulatory agencies introduced the concept of Reduced Vertical Separation

Minimums (RVSM) to help alleviate aircraft congestion in high-use areas. RVSM reduced the vertical separation requirements from 2,000 feet to 1,000 feet for aircraft in the higher flight levels (over FL290). By 2005 RVSM was fully implemented from FL290 to FL410.

The move to Automatic Dependent Surveillance-Broadcast (ADS-B) using GPS technologies was developed as part of an effort to safely increase capacity and lower the cost of operations compared to current ground-based secondary surveillance radar networks.

An effective solution

Not long after the implementation of GPS in civilian airspace for navigation, the industry, encouraged by the FAA, began considering using GPS position information for tracking aircraft with an enhanced position reporting capability. The foundation technology for ADS-B had been around, in concept, for some time. The transceivers work differently from traditional transponders (interrogation/reply). Instead of radar interrogating and

the transponder replying to the radar site when asked, with ADS-B the transceiver in the aircraft broadcasts its location and discrete ICAO data (generated from its GPS and other sensors on the aircraft) approximately every second. The ADS-B ground station receiving the broadcast processes the information and transmits it to the ATC facility where it is graphically displayed on the controller’s workstation. This concept reduces the need for the somewhat expensive ground infrastructure of secondary surveillance radars currently in use—with the added benefit of more rapid updating of position, significantly better aircraft position resolution and other information particular to the transmitting aircraft (intent, heading, etc.).

A companion benefit of the ADS-B scheme is that properly equipped aircraft can receive the ADS-B information from other aircraft and display it to the pilot—an enhancement that allows pilots better traffic awareness with additional precision and information on the specific aircraft transmitting the ADS-B signal.

The proof

The first U.S. trial was the Capstone Program in Alaska. According to the FAA, which implemented the project in partnership with industry, Capstone was aimed at boosting safety and also improving the efficiency of operations in a state dealing with poor weather conditions, challenging terrain and a lack of ground-based radar.

The FAA equipped 140 aircraft with ADS-B OUT/IN using the UAT 978MHz frequency. The UAT transceivers allowed for both aircraft-to-ground and aircraft-to-aircraft information exchange. The fleet also received in-cockpit display screens for visualizing the traffic, terrain and weather.

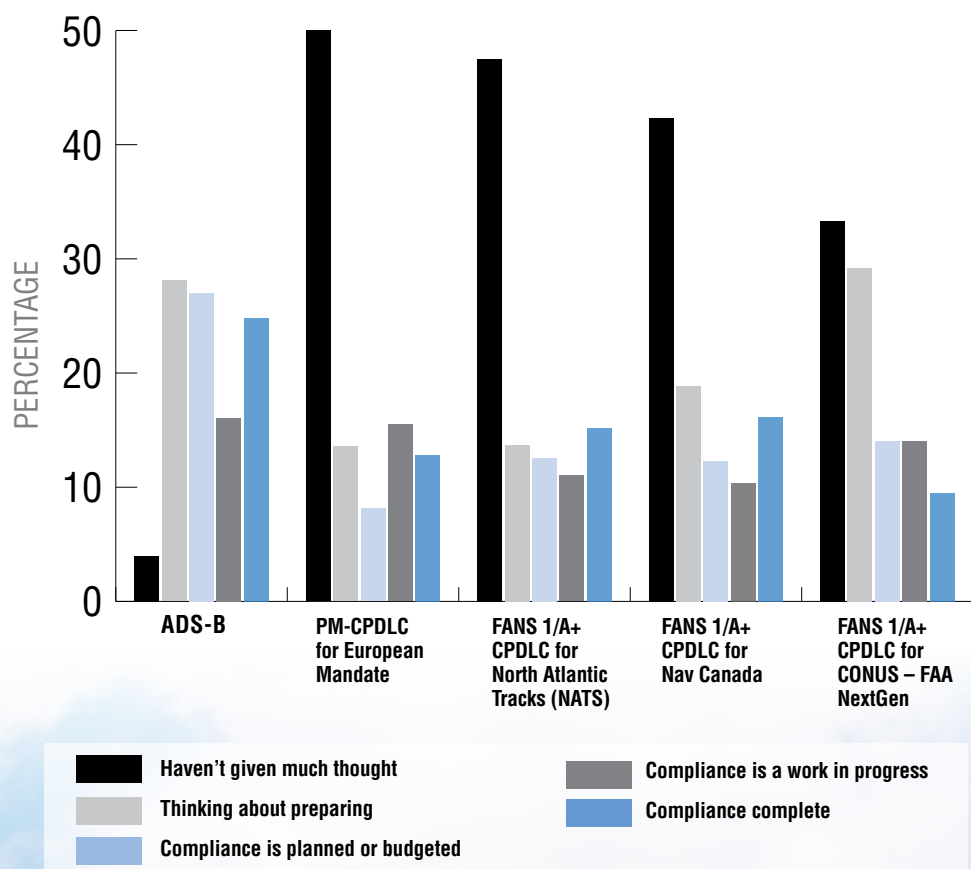
Implementing of ADS-B through Capstone reduced the overall aircraft accident rate by 40 percent in Alaska between 1999 and 2006. It was a dramatic demonstration of the power of ADS-B to help pilots self-separate from other traffic, terrain and weather.

The Capstone program was considered a success, but the designers of the study did learn that basic GPS wasn’t quite good enough for ADS-B. Phase 2 of the program included the implementation of wide-area augmentation systems (WAAS) for enhancing GPS accuracy to allow precision approach navigation. The Capstone results were used to develop the performance and many of the equipment standards that make up today’s ADS-B 2020 mandate in the U.S.

Beyond Capstone, a trial with United Parcel Service aircraft showed that an ADS-B IN/OUT-equipped fleet of aircraft could be sequenced via software to fly continuous descent profiles with minimal ATC interference. The noise and emissions reductions of more than 30 percent, plus fuel

LEVEL OF READINESS FOR THE MANDATES

This analysis is based on a blind online survey conducted with **Aviation International News** to gauge awareness and readiness for impending international aviation regulatory mandates. Results are tallied from 278 respondents, including operators, pilots, airlines, and corporate flight departments, who participated in the June 2015 survey.



savings of 500 pounds per aircraft per approach were compelling evidence that ADS-B was good technology. More recent international trials involved a Honeywell Aerospace-equipped Boeing 747-400 fleet in the South Pacific. Twelve aircraft demonstrated the effectiveness of ADS-B IN/OUT capability for in-trail procedures.

Between 2009 and 2014 FAA completed installation of ADS-B ground stations across its National Airspace System (NAS).

Dual-link ADS-B's role in NextGen

ADS-B is now a key factor in the revamp of the entire U.S. National Airspace System, NextGen, and concurrently a large component of the Single European Sky airspace revamp, as well. There are operator-cost burdens. But there are also tangible operator operational improvements/savings as well as safety enhancements.

The ADS-B technology provides controllers with updated aircraft position information every second; radar provides those updates every seven to 12 seconds. In the U.S. more than 120 air traffic control sites receive ADS-B data, and ATC can now see traffic in areas where there is no radar coverage. Aircraft flying in the U.S. can now receive traffic, weather, NOTAMs and TFRs via 978MHz UAT receivers that can cost less than US\$1,000. Inexpensive portable UAT receivers (ADS-B IN) that can relay FIS-B and TIS-B information to consumer tablet-based EFBs have proliferated in the U.S.

ADS-B is an international initiative

ADS-B is being implemented all over the world, and is proving to be efficient and cost effective for safely separating aircraft in countries where radar was non-existent and air traffic control services are basic, at best. Most countries are deploying an ADS-B infrastructure based on the 1090 Mhz Extended Squitter (1090ES) datalink. The 1090ES ADS-B technology can make TCAS more accurate, but it is not a replacement for TCAS. ADS-B integration with TCAS was done as part of TCA-SII Change 7, which was completed in 1999. The 1090ES does not do ADS-B IN.

Australia is now equipped with enough ADS-B ground stations that the continent is one of the first to require its operators to be ADS-B equipped in order to fly above FL290. Southeast Asia also has a number of existing and near-term ADS-B requirements with Hong Kong and Singapore, for instance, right behind Australia with equipage deadlines. The U.S. and European equipage deadlines are Jan. 1, 2020 and May 2020, respectively.

The U.S. adopted the 1090ES ADS-B OUT requirement for all aircraft operating in Class A (above 18,000 ft msl) airspace. Aircraft that operate exclusively below 18,000 ft msl (and less than 2,500 ft agl)

can still meet the ADS-B OUT standard with a 978 MHz UAT transmitter. Any operator that wants the benefit of FIS-B weather via ADS-B IN needs a 978 MHz UAT receiver installed in the aircraft. To make the two-frequency system work, signals are broadcast from one frequency to the other and to ATC.

The standards for ADS-B appeared set when the FAA published DO-260 and then -260A. Early adopters began equipping their aircraft. And then the standard in the U.S. changed. (It was too late for several other countries that are early implementers of the system, including Australia. They require only DO-260A provisions.)

As of 2015, aircraft upgrading to ADS-B in the U.S. and Europe must follow the protocols in DO-260B. WAAS GPS is one way (and generally the easiest way) to fully comply with the position accuracy and integrity requirements. The FAA has agreed to grant temporary exemptions to the position requirements out to Dec. 31, 2024 that enable use of SA-aware receivers with no restrictions and SA-on receivers with some restrictions.

Choices: UAT or 1090ES?

Honeywell has both. You might, too.

"Here at Honeywell we know that some 10,000 of our customers and at least that many of our Bendix/King customers will need to retrofit their aircraft to meet ADS-B mandates going forward," said Miller. To help provide information to Honeywell and Bendix/King customers, the

company is educating its Tech Operators on ADS-B, and partnering with MROs to develop STCs for the numerous airframes currently operating with its avionics.

Avionics sales representatives at Duncan Aviation, a key MRO partner with Honeywell in the re-equipage of its customer fleet, deal with the questions from owners on a daily basis now, according to Mark Francetic, regional avionics sales manager for Duncan. "We have an entire section of our website devoted to ADS-B upgrades," he said. "In 2013 we went on the road with ADS-B and NextGen seminars, offered for no charge, just to get the word out in the U.S. We started by talking about FANS/1A, but ADS-B was added quickly to the line-up," he continued. Duncan offers the seminar six times a year in locations spread across the U.S.

How to equip, and the questions to ask

Avionics manufacturers such as Honeywell Aerospace have been working with aircraft manufacturers to make sure that their customers have solutions in place well before the 2020 mandates go into effect. They know it takes time for operators and owners to come online and realize they need this equipment. And then it takes time for them to figure out exactly what equipment they will need.

"These customer conversations are straightforward," explained Steve Eloffson, avionics sales representative for Duncan. "A lot of the time our first question to the owner/operator is

- *'Do you fly your airplane exclusively domestically in the U.S. or do you take it out of the country?'*

The questions continue from there:

- *'Do you fly above FL180?'* If yes, then you'll want a 1090ES solution.

- *'Do you already have TCASII?'* If yes, then you'll want a 1090ES solution, and you should take the opportunity to upgrade to TCAS 7.1 at the same time.

- *'Do you already have a source of onboard weather, plus NOTAM and TFR delivery system?'* If yes, then you might want to begin your ADS-B upgrade with a 1090ES solution.

There are arguments for carrying both UAT and 1090ES on board in the U.S. The volume of information transferred via UAT and its ability to be depicted on inexpensive tablet-based EFBs via Wi-Fi or Bluetooth are both good reasons to equip.

Part 23 aircraft

"There are good options for smaller business aircraft that are certified under 14 CFR Part 23 rules," said Duncan Aviation's Francetic. Retrofit packages might require only a new or updated transponder, or the addition of a UAT transceiver and a cockpit display unit.

Operational Privacy and ADS-B

There are concerns that ADS-B removes anonymity during VFR aircraft operations, because the ICAO 24-bit transponder code specifically assigned to each ADS-B-equipped aircraft allows monitoring of that aircraft when within the ATC system.

Unlike the Mode A/C transponders, there is no 1200 code with ADS-B OUT to offer anonymity. That Mode-S/ADS-B identifies the aircraft uniquely among all in the world, in a similar fashion as a MAC number for an Ethernet card or the International Mobile Equipment Identity (IMEI) of a GSM phone.

The FAA is allowing UAT-equipped aircraft to use a random self-assigned temporary ICAO address in conjunction with the use of beacon code 1200. The problem is that 1090ES equipped aircraft using ADS-B don't have this option. The question is, could they?

The industry group Equip 2020 is working on a solution, based on early research to create "anonymity" functions for the 1090ES transponder.

The NextGen GA Fund will loan U.S. operators the money for the upgrade. There are dozens of STCs available for light aircraft, and it isn't necessarily difficult to obtain field approvals for simple stand-alone installations of UAT transceivers or 1090ES transponders.

Part 25 aircraft and 1090ES

Owners of larger, faster, more capable aircraft don't have it so easy. Most aircraft certified under 14 CFR Part 25 have already been hit with the need to upgrade other components of their avionics to comply with the NextGen mandate. Most often these upgrades are installed when the aircraft is down for other maintenance. "We tell customers it is a two- to three-week install process," said Elofson. "We have to pull the transponders out of the airplane and send them to the OEM for modification. The new wiring goes into the airplane while we wait for the transponder," he explained.

"When you get to Part 25 things get more complicated, more expensive and time consuming," said Francetic. "In 2014 it took one field approval nine months to make it through the process. None of the FAA maintenance inspectors want the liability of signing these installations off, so they kick it up the ladder, and then it gets kicked back down again," he said. "And we hear from the FAA that 30 percent of those field approved installations don't work in real life operations."

What does work are Service Bulletins from aircraft manufacturers and STC'd installations, which are provided by avionics manufacturers such as Honeywell Aerospace. The OEMs and avionics companies are working tirelessly to provide those flying their equipment with straightforward upgrade paths that meet the 2020 mandate.

"Owners operating with legacy aircraft—a Hawker, for example, with Sperry Primus systems—they may need a radio controller upgrade, or more. We've taken an approach of giving them several upgrade paths, from just a transponder to adding WAAS capabilities, or more," said Honeywell's Miller.

Honeywell Primus 1000/2000 and SPZ-8000 flight decks are on multiple Hawker 800-series aircraft. Select Cessna Citation 560s are equipped with the Primus II radio system.

"Honeywell, through its MROs, has completed more than 1,200 ADS-B OUT upgrades already," said Miller. "We started the Primus II and Epic very early, and that has helped with working the bugs out," he explained.

"Then on the lighter end we are working the Primus APEX solution [Pilatus PC-12 and Viking Twin Otter] driven by the Royal Flying Doctors

Association in Australia's needs. They have 50 PC-12 operators who needed ADS-B. We have many thousand KT 73 transponders to replace with the KT 74," he continued.

Equip when? Now. Yes, now!

A recent Honeywell survey showed that 28.1 percent of respondents were "thinking about complying with ADS-B before 2020" whereas 27 percent were scheduling upgrades, 16 percent were in the process of compliance, and a mere 24.8 percent of those surveyed operated aircraft that they believe are already meeting the DO-260B mandate for ADS-B OUT.

Yet chief NextGen officer and deputy FAA administrator Michael Whittaker reiterates this statement at every event he attends. "The deadline for ADS-B OUT equipage in the U.S. is January 1, 2020. After that date, if you don't have ADS-B OUT, you won't be flying inside Class A, B or C airspace without a waiver." And for those of you who think that date is a long way off, think again.

"As of the end of August 2015 there were 15,000 aircraft in the U.S. flying with ADS-B OUT," stated Jens Hennig, v-p of operations for the General Aviation Manufacturers Association, and a member of the Equip 2020 working group. "Interestingly, the majority of those now equipped are piston-powered aircraft, even though many business jet avionics manufacturers have STC solutions in place, or will have them in place by 2016," he continued.

FAA data indicates that the agency expects the number of equipped aircraft to increase by 50 percent each year, and yet even at that rate it expects less than 100,000 aircraft to be equipped by 2020.

"Feedback from our MRO members tells us that they are now hearing from customers who want to book time for the upgrades in 2018 and 2019," Hennig said. "More people should be considering that right now."

One reason MRO members are worried is because the math doesn't work out. There simply aren't enough qualified avionics technicians out there right now to upgrade even the 70,000 airplanes the FAA forecasts will comply with the mandate in time.

Even on a smaller scale the numbers are daunting. Duncan Aviation's Francetic put it this way: "I've got an operator in Montana with 28 King Airs. He wants to upgrade them to ADS-B IN/OUT when the aircraft are scheduled down for maintenance, at the rate of four per year. There is simply no way they will all be upgraded in time," Francetic said.

Hennig and Francetic aren't alone in worrying that owners and operators in the U.S.

are procrastinating. Ric Peri, v-p, government and industry affairs for the Aircraft Electronics Association, said, "I think procrastination is human nature. That said, if you can benefit from ADS-B IN, you should have your airplane in the queue for the upgrade yesterday. At the very least, you could have the wiring done at the next annual inspection. With ICAO adding transoceanic routes and the maturation of ADS-B mandates in Asia and Australia, airplanes without the upgrades will hold less value down the road."

Duncan Aviation's Elofson agrees. "We are [currently] getting people scheduled all the way out to 2019, even where we don't have an STC or SB solution for their avionics yet. They just want to make sure they have a slot."

"We are trying to give Honeywell customers options," explained Miller. "But now is the time to be researching the upgrade and making decisions. I believe that we will be in an allocation process at our MROs because there will be no open slots for servicing, come close to the mandate deadline. You may not be able to get into the most qualified shop that you want because you waited too long," he cautioned.

Will the mandate enforcement date move? It is impossible to say. Even if it does, it won't necessarily move out far enough to accommodate all the aircraft that will require upgrades to meet it. And will the avionics get less expensive? Perhaps. But shop rates certainly will not if there is great demand.

If you own or operate an aircraft that flies in airspace where you'll need ADS-B, you owe it to yourself to begin the research into the upgrade project today.

Use this white paper as a principal reference, and reach out to your avionics OEM, aircraft OEM or principal maintenance provider for more information on Service Bulletins or STCs available for your aircraft.

Additional Resources

- ▶ <https://pages3.honeywell.com/mandates>
- ▶ pilots.honeywell.com
- ▶ duncanaviation.aero/nextgen
- ▶ faa.gov/nextgen/update/operator_investments_and_airports/operator_investments/adsb/
- ▶ nextgenfund.com/gafund/
- ▶ Honeywell Aerospace, Inc.
U.S./Canada (800) 601-3099 (Toll Free)
International (602) 365-3099