ADS-B Essentials: Part 1

ADS-B installations are beginning to take off

BY DAVID HUGHES, NEXTGEN PERFORMANCE AND OUTREACH, FEDERAL AVIATION ADMINISTRATION

Mike Hall equipped his high-performance single-engine aircraft with ADS-B (automatic dependent surveillance-broadcast), but it had a glitch.

The New York general aviation pilot upgraded his transponder to include 1090 ES (extended squitter) capability in 2010, and thought he was all set to broadcast ADS-B Out. But he didn't realize he would also need a software upgrade and an additional wire to make sure the WAAS (wide area augmentation system) was feeding the ADS-B Out broadcast properly.

Mike Hall

"My airplane was not broadcasting ADS-B signals when I thought it was," Hall said. "I went back to the shop for the wire and the software. Now I fly a fully ADS-B compliant aircraft that meets the FAA's 2020 mandate." Hall has equipped his aircraft with UAT (universal access transceiver) capability on 978 megahertz, as well.

As an early adopter of new technology, Hall finds the ADS-B In traffic and weather information useful as he flies for business and pleasure. He believes things will get easier for general aviation as equipage progresses in the next few years.

The nationwide ADS-B infrastructure has been completed with 634 ground stations installed. The upgraded surveillance and broadcast system is capable of providing aircraft position information to controller screens at a much higher rate than the current radar-based system.

As of May 1, 2014, there were 4,755 civil aircraft of all types equipped with the proper version of ADS-B Out for the ADS-B mandate. Two-thirds of these were fitted with 1090ES and about one-third with UAT. The remaining three percent were

THIS STORY WAS ORIGINALLY PUBLISHED IN THE JUNE 2014 ISSUE OF *AVIONICS NEWS* MAGAZINE, A MONTHLY PUBLICATION OF THE AIRCRAFT ELECTRONICS ASSOCIATION.

broadcasting on both 1090ES and UAT. About 100 of the 230 air traffic control facilities across the country are already using ADS-B to separate traffic, and all of them will be doing so before the mandate for equipage takes effect.

TIS-B (traffic information service-broadcast) provides track information on transponder-only aircraft that are being detected by air traffic control radar to ADS-B In equipped aircraft. The TIS-B service is provided within a 15-nautical mile radius, up to 3,500 feet above or below the receiving ADS-B In aircraft's position. A general aviation aircraft equipped with ADS-B In can also receive position data directly from other aircraft broadcasting on the same ADS-B Out frequency. ADS-R (automatic dependent surveillance–rebroadcast) relays position information broadcast by ADS-B avionics on the 1090 MHz ES link to aircraft receiving data on the 978 MHz UAT link and vice versa. The ADS-R service is provided within a 15-nautical mile radius and plus or minus 5,000 feet of airspace volume relative to the receiving aircraft's position.

Many avionics repair shops contacted by the Federal Aviation Administration for this article have already installed ADS-B equipment on a dozen or more aircraft to meet the agency's 2020 equipage mandate. The FAA wants to assist them and aircraft owners with guidance on how to complete installations correctly. Proper adherence to certain technical details is essential.

There are about 150,000 unequipped aircraft that need to have ADS-B Out installed. Based on this, the FAA and repair shops are recommending that aircraft owners begin accomplishing installations as soon as possible. This will help aircraft owners avoid being caught in the expected rush of activity leading up to the 2020 deadline.

When aircraft are equipped with ADS-B Out, controllers are provided with increased position updates and without need for interrogation by ground-based radar systems.

"One of the things I tell people is that right now there may be no hurry, but they shouldn't let the ADS-B installation go past 2016," said John DenDekker, general manager for Carpenter Avionics at Smyrna Airport in Smyrna, Tennessee. "The last three years of installations before the mandate will be crazy. Waiting until then means a pilot can't take advantage of ADS-B In services, which are being broadcast to aircraft today."

Transponder-equipped aircraft that fly in controlled airspace today will need ADS-B Out when the mandate takes effect in 2020. That's far enough away that many ADS-B installations can be done now when aircraft are in for other work.

"If we are doing installation work on an aircraft, ADS-B is just an add-on right now," said Chuck Gallagher, manager of Cincinnati Avionics at the Clermont County Airport in Batavia, Ohio. "If the aircraft is opened up for other avionics work, ADS-B is not a hard sell."

Gallagher also expressed concern that general aviation aircraft owners will wait until the last minute to add ADS-B, and by then there may not be enough capacity at U.S. repair shops to equip them all by the deadline.

Repair shop operators say aircraft owners and operators may be delaying because they are confused about what to do. But the experience of early adopters is helping the general aviation community understand how to proceed. To make installation easier to understand, the FAA Flight Standards Service's Aircraft Maintenance Division is providing a list of frequently asked questions and a checklist to guide repair shops:

Continued on following page

ADS-B INSTALLATIONS

Continued

- ***ADS-B Transmitters and Position Sources.*** *(See **ADS-B Essentials, Part 2**)*
  This list of frequently asked questions explains that ADS-B transmitters must be compatible with installed GPS position sources. The transmitters and position sources cannot be mixed and matched. They must be installed in approved pairings detailed in a list of equipment on this FAQ that meets FAA certification requirements. This list is current as of April 2014.

- ***ADS-B Avionics Installation Guidance.*** *(See **ADS-B Essentials, Part 3**)*
  This checklist provides guidance on the installation of approved ADS-B Out avionics on aircraft with a standard airworthiness certificate as well as the installation of uncertified ADS-B Out avionics on aircraft with an experimental airworthiness certificate. The checklist also covers common problems involved in such installations and briefly explains how to deal with them. It discusses how to install both a 1090 MHz ES and a UAT system on the same aircraft. When properly configured, these systems allow pilots to take full advantage of available ADS-B broadcast services and capabilities at all altitudes.

According to DenDekker, avionics manufacturers have provided PowerPoint presentations to help educate aircraft owners and operators on ADS-B. He has provided presentations for his own customers. Other shops, such as Pacific Coast Avionics at Aurora State Airport in Aurora, Oregon, are providing similar information. "We try to break it down and make it as simple as possible," said Dewey Conroy, vice president and chief operating officer for Pacific Coast Avionics. "Very few people are coming through the door having figured it all out."

Many shops report considerable general aviation interest in ADS-B In, which includes traffic awareness capability from TIS-B and weather capability from FIS-B (flight information service-broadcast). TIS-B and FIS-B services are available across most of the U.S. The ADS-B In avionics needed to provide TIS-B traffic awareness capability costs less than other traffic awareness systems available. In addition, there is no monthly subscription fee for the use of FIS-B weather data.

In some cases, customers are opting for a single system that provides ADS-B In and Out capabilities, including the display of traffic and weather information on a panel-mounted display. Others prefer displaying TIS-B and FIS-B on tablet computers.

Recently, Hall was flying with his son, who was piloting the Mooney into New York City. Hall monitored the traffic picture on a tablet.

"I could see the traffic flow into New York City airports from 50 miles away, and it gave me an idea of how busy the world was," he said.

When Hall saw four aircraft on the display lined up in a conga line headed into Westchester County Airport, he knew his son would be directed to follow this line to land at the airport. When a pilot knows what to expect, he can plan his next move on the airspace chessboard.

As Hall discovered, there are technical nuances that can make a difference in getting an ADS-B installation right the first time. More often, problems with installations that the FAA has identified in monitoring ADS-B avionics compliance have occurred with uncertified equipment installed on experimental aircraft. Guidance on what to do in these cases is included in the checklist, which appears later in this article, titled "FAA ADS-B installation guidance." The guidance should help a repair shop that is involved with one of these types of installations or when the operator of an experimental aircraft asks for installation advice regarding uncertified avionics.

Want to know how well your ADS-B system is performing? Send an email to 9-AWA-AFS-300-ADSB-AvionicsCheck@faa.gov identifying your aircraft's registration number (N-number) and request a system check.

Frequently asked questions about ADS-B avionics installations

What are the rules?

The Federal Aviation Administration published two rules in the Code of Federal Regulations in May 2010: 14 CFR 91.225 and 14 CFR 91.227. Effective Jan. 1, 2020, aircraft operating in the airspace defined in 14 CFR 91.225 are required to have an ADS-B system to include a certified position source capable of meeting the requirements defined in 14 CFR 91.227. Aircraft operating in Class A airspace — from 18,000 feet mean sea level to and including Flight Level 600 — must broadcast position data using Mode S, 1090 ES. Aircraft operating in designated airspace exclusively below 18,000 feet MSL can broadcast the required information using either 1090 ES or a UAT on 978 MHz.

While the compliance deadline is 2020, the FAA is encouraging owners to equip their aircraft with ADS-B well before the mandate goes into effect. The improvement in situational awareness for pilots greatly increases safety.

Which type of ADS-B equipment should an avionics shop install?

There are two types of ADS-B systems:

1. Mode S transponder-based equipment certified to technical standard order (TSO)-C166b.

2. UAT equipment certified to TSO-C154c.

If an aircraft owner plans to operate above FL 180 or internationally, he or she should be equipped with Mode S Transponder.

If an owner plans to operate only below FL 180 within U.S. airspace, he or she can equip with Mode S transponder or with UAT equipment. UAT equipment provides the ability to receive traffic and weather data from two no-cost broadcast services, TIS-B and FIS-B. TIS-B can be received on 1090 MHz, but not FIS-B.

Which type of position source should an avionics shop install?

The FAA recommends a TSO-C145 or TSO-C146-compliant WAAS GPS. These units are readily available for general aviation and provide sufficient performance to meet the 14 CFR 91.227 requirements. General aviation avionics vendors offer stand-alone receivers and package them with the ADS-B transmitter or with a GPS navigator.

Can an avionics shop match any ADS-B equipment with any GPS equipment?

No, an ADS-B transmitter must be compatible with its installed GPS receiver. ADS-B equipment manufacturers are beginning to identify this compatibility (see the list titled, “ADS-B equipment that meets FAA certification requirements”). Mixing GPS systems with ADS-B units in the field is not permitted unless the equipment combination is shown to be compatible via a previous FAA certification effort, e.g., supplemental type certificate. Contact the manufacturer to learn which GPS systems are approved for a particular ADS-B system.

Some manufacturers are marketing uncertified ADS-B transmitters. Can these be installed?

Aircraft owners may install an uncertified transmitter on an amateur-built aircraft with an experimental airworthiness certificate. The FAA, however, strongly discourages the use of uncertified ADS-B Out equipment even in experimental aircraft. Uncertified equipment, including uncertified

Continued on following page

transmitters, should not be installed on any aircraft with a standard airworthiness certificate. Uncertified ADS-B transmitters do not comply with 14 CFR 91.227 and will not be permitted to operate in airspace requiring ADS-B starting in 2020.

Air traffic control does not use data from these uncertified transmitters, which prevents controllers from providing flight following services or separation services to aircraft that are so equipped. Data from uncertified transmitters are not displayed on certified ADS-B In displays, and pilots in aircraft with certified ADS-B equipment will not be able to see aircraft equipped with uncertified transmitters.

Can an aircraft owner or avionics shop install an uncertified GPS as an ADS-B position source?

Aircraft owners or avionics shops may install an uncertified GPS on amateur-built aircraft and light sport aircraft with experimental airworthiness certificates. Uncertified equipment, including uncertified GPS units, should not be installed on aircraft with standard airworthiness certificates. These position sources do not comply with 14 CFR 91.227 and will not be permitted to operate in airspace requiring ADS-B starting in 2020.

As with uncertified transmitters, uncertified GPS integrated into an ADS-B system will transmit data that cannot be used by ATC or other certified ADS-B In systems. Contact the manufacturer to learn which GPS systems are approved for a particular ADS-B system.

What are the risks of using an uncertified position source?

The risk with any GPS receiver, when used to support separation services, is the potential for position measurement error without detection. If the position error is too great, ATC would not be able to provide safe separation between one aircraft and other traffic in the vicinity. The FAA and international partners conducted a safety analysis prior to publishing the ADS-B final rule to define the error detection boundary, and ADS-B performance requirements are based on this analysis.

Certified GPS sensors compare GPS satellite measurements against each other. When a satellite signal error becomes great enough to detect, the receiver will reject that signal. The integrity performance specified in the ADS-B rule depends on the proper operation of this error detection feature that ensures the safety of using ADS-B position based on GPS measurements. Navigation Integrity Category specifies an integrity containment radius around an aircraft's reported position, as defined in TSO-C166b and TSO-C154c 14 CFR 91.227. The NIC radius (bubble around aircraft) must be 0.2 nautical miles.

By comparison, uncertified commercial-grade GPS sensors assume the system is working properly and do not attempt to detect errors in satellite measurements. When presented with an erroneous measurement, these GPS sensors will calculate an erroneous position. FAA safety analysis found this to be unsafe. Therefore, ADS-B position information based on these sensors is prohibited from being used to support air traffic separation services and ADS-B air-to-air operations.

What equipment is available?

Approved avionics are available from multiple manufacturers. The list titled, "ADS-B equipment that meets FAA certification requirements" is current as of April 2014. Check with the avionics manufacturer for the latest updates on which GPS position solutions can be matched with a particular ADS-B unit.

Several manufacturers have products in development that will be available to meet the 2020 mandate for ADS-B Out. Some approved GPS receivers are also certified GPS navigators. They may be installed to support precision approaches in addition to providing ADS-B position information. In some cases, the GPS receiver may be integrated with a multifunction display providing a moving map, an ADS-B traffic display, access to the FIS-B information and more.

ADS-B equipment that meets FAA certification requirements

The FAA does not endorse any product or manufacturer listed. These pairings of ADS-B and position sources are listed in order of when the supplemental type certificate was issued. *Source: Federal Aviation Administration*

Manufacturer	ADS-B Model Number	Approved Position Source
ACSS	XS-950	RCI GLU-920 , RCI GLU-925
Honeywell	XS-852	CMC CMA-4024-1 SBAS
Trig Avionics	TT-31	FreeFlight WAAS 1201 Accord Technology NexNav Mini GPS unit
FreeFlight Systems	FDL-978-TX	FreeFlight WAAS 1201
ACSS	XS-950	RCI GLU-920 (A320), Thales TLS8755-01-0101A/0102B (A330)
Honeywell	ISP-80A.1	Honeywell ADIRU Part Numbers (P/N) HG2030BE02, BE03 or BE04
Trig Avionics	TT-22	FreeFlight WAAS 1201
Garmin	GDL 88 GTX 23 GTX 33x w/ES GTX 330x GTX 3000 (GTX models require appropriate S/W rev)	Garmin GTN 625/635/650, GTN 725/750, GPS 400W, GNC 420W/420AW, GNS 430W/430AW, GPS 500W/530W (w/ or w/o TAWS) (all require appropriate S/W rev)
Honeywell	MRC XPDR w/ADS-B Out	CMC CMA-3024 SBAS GNSSU MK II and CMA-4024 SBAS GNSSU
Honeywell	XS-858B Transponder, P/N 7517402-970	Honeywell GPS module (made by CMC), P/N 245-604067-100
Honeywell	XS-858B P/N:7017401-970	Honeywell GNSS/MMR VIDL-G, P/N: 7026208-804
NavWorx	ADS600-B	Accord Technology NexNav Mini GPS unit
FreeFlight Systems	FDL-978-XVR	FreeFlight WAAS 1201 (either external or integrated in FDL-978-XVR)
Rockwell Collins	TDR-94D-550	Universal UNS-1Fw
Avidyne	AXP340	Avidyne GPS (including R9) Garmin GNS430W/530W Garmin GTN650/750 FreeFlight Model 1201/1204 NexNav mini-T (external)
BendixKing	KT-74	Accord NexNav Mini GPS unit FreeFlight WAAS 1201

Continued on following page

FAA ADS-B installation guidance

Guidance on the installation of ADS-B Out avionics for aircraft with a standard airworthiness certificate; these aircraft can broadcast ADS-B data on 1090 ES avionics and/or on 978 MHz UAT avionics.

1. Refer to AC 20-165A for guidance on the installation and testing of ADS-B Out avionics on aircraft with a standard airworthiness certificate.

2. ADS-B Out avionics must be approved by the FAA with a TSO (technical standard order) when installed on an aircraft with a standard airworthiness certificate. Approved ADS-B Out avionics will be marked with either TSO-C166b (1090 ES) or TSO-C154c (UAT) on the equipment's attached data plate. Do not install non-TSO ADS-B avionics on Part 23 and Part 25 aircraft, or Part 27 and Part 29 rotorcraft.

3. Installation of approved ADS-B avionics on an aircraft with a standard airworthiness certificate must be through a supplemental type certificate, approved model list associated with an STC, or field approval under certain conditions. Refer to the FAA policy memo for more information at www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs300/media/Major_Repair_Alteration_Job-Aid.pdf.

Guidance on the installation of uncertified ADS-B Out avionics (1090 ES or UAT) on amateur-built aircraft and light sport aircraft that have experimental airworthiness certificates:

- Non-TSO ADS-B Out avionics may be installed on amateur-built and light sport aircraft with experimental airworthiness certificates. In such installations, the ADS-B Out system must be configured to transmit a system integrity level and system design assurance of zero (SIL/SDA=0). The SIL/SDA=0 settings prevent ADS-B data of unknown quality and integrity from being processed by ATC automation and other ADS-B equipped aircraft but allow for the avionics to receive FAA traffic and weather broadcast services: TIS-B and FIS-B. Contact the manufacturer of non-TSO ADS-B Out avionics for instructions on how to ensure SIL and SDA parameters are configured properly prior to operation.

Guidance on the installation of both 1090 ES and UAT ADS-B systems on the same aircraft:

- It is acceptable to equip an aircraft with both a 1090 ES and UAT ADS-B Out system. When properly configured, such installations allow pilots to take full advantage of available ADS-B broadcast services and capabilities. Care must be taken to ensure the systems are configured properly to avoid possible issues with ATC and other ADS-B aircraft. The FAA recommends that aircraft equipped with both a 1090 ES and UAT system be configured to transmit ADS-B data from the 1090 ES system only and set to receive data on both systems (if applicable). This configuration will comply with all ADS-B Out airspace equipment requirements and maximize use of ADS-B broadcast services (TIS-B and FIS-B). The FIS-B service is available only with UAT systems over the 978 MHz frequency.

Use of portable ADS-B Out systems: Portable ADS-B Out systems, also known as "suitcase" units, should not be operated (transmitting) aboard any aircraft. While marketing associated with these units may imply approval for use by way of an FCC license, the FAA prohibits their use for the following reasons:

1. The positioning of portable, suction-cup GPS antennas associated with these units often require they be affixed to front or side windows or glareshield to obtain a usable signal. Such antenna placement obstructs the pilot's view. Wiring connecting the antennas to the suitcase unit also interferes with aircraft controls and instruments.

2. ADS-B Out avionics require the transmission of a valid Mode S code to operate properly with ATC

automation and other ADS-B aircraft. Mode S codes, also known as the ICAO code, are assigned to an aircraft during registration and then programmed into transponders and ADS-B Out avionics. Mode S codes remain static until a change in aircraft registration or identification (N-number) occurs. Portable units require users to input the Mode S code assigned to each aircraft flown. A high number of Mode S code entry errors have occurred with this procedure, which prevent proper target correlation within ATC automation systems (target drops). Errors have resulted in increased workload and unnecessary distractions for pilots and controllers.

Use of portable ADS-B In systems: Use of portable ADS-B In "receive-only" units is acceptable under the provisions of 14 CFR §91.21(b)(5) & (c). These units are limited to listening for ADS-B signals and do not interact with ATC automation or other ADS-B equipped aircraft. Users of portable ADS-B In units should be aware that traffic information broadcasts from TIS-B are initiated by ADS-B Out aircraft transmitting within a service volume. Therefore, when an ADS-B service volume does not detect the presence of ADS-B Out aircraft, users of receive-only units in the same service volume will not be provided with transponder-based traffic information (TIS-B).

Common problems following ADS-B installations:

1. Mode 3/A code processing between transponder and UAT.
    - In Dual ADS-B Out systems, the transponder control panel is typically used to input the Mode 3/A code, which is then sent to the UAT for broadcast. When this transfer is not accomplished correctly, a Mode 3/A mismatch occurs between the transponder and UAT broadcast, causing ATC conflict alerts.

2. Non-compatible position source (GPS).
    - If a position source is used that isn't approved for use with the ADS-B system, or an approved position source is used but isn't using the appropriate software version to perform critical calculations, misleading data can be transmitted, resulting in a hazardous situation. Examples include incorrect position, velocity, integrity and/or accuracy information.

3. Mode S code programming errors.
    - The current Mode S code assigned to the aircraft during registration must be programmed into the ADS-B transmitter at installation. If equipping with both a 1090 ES and UAT transmitter on the same aircraft, the correct Mode S code must be entered into both transmitters and verified. Incorrect Mode S codes will cause issues within ATC automation. Mode S code mismatches on dual-Out equipped aircraft will cause ATC conflict alerts.

4. Improper SIL/SDA configuration on non-TSO units (experimental amateur-built and light sport aircraft).
    - The installation of non-TSO ADS-B equipment on experimental e-AB and e-LSA aircraft is allowed but requires the SIL/SDA parameters to be configured to transmit values of zero. A SIL and SDA=zero configuration prevents ADS-B data of unknown quality and integrity from being processed by ATC automation and other ADS-B In equipped aircraft.

5. Aircraft with ADS-B Out capable Mode S transponders installed that comply with TSO-C166a but were misconfigured during installation to transmit as compliant to TSO-C166b.
    - This problem typically occurs during installation of a UAT Out system on an aircraft with an existing TSO-C166a compliant Mode S transponder and results in the aircraft transmitting bad ADS-B Mode S data and good UAT data.

How to avoid problems:

1. Use a Part 145-certified repair station with appropriate limited ratings to complete and test the ADS-B installation. An ADS-B avionics manufacturer can provide aircraft owners with a list of recommended service centers to accomplish this work.

2. For ADS-B installations on experimental e-AB and e-LSA aircraft, use appropriate ramp test equipment to verify system performance. The built-in test capabilities of individual ADS-B avionics components are not sufficient to verify proper operational performance of the entire system. ❑