FAA Navigation Programs AJM-32
http://gps.faa.gov

SatNavNews

Past, Present, and Future

The WAAS Prediction Tool Extends WAAS Analysis to Forecast Future Performance

Since the FAA commissioned WAAS into service in July 2003, the WAAS Test Team at the William J. Hughes Technical Center has reported real time and historical performance of the system. The latest objective, however, is to demonstrate WAAS performance in the future. To meet this goal, the WAAS Test Team developed a tool to predict future WAAS performance.

The WAAS prediction tool forecasts WAAS availability for each airport that has published Lateral Precision (LP) and Lateral Precision with Vertical Guidance (LPV) procedures. The FAA has published over 4,500 LP and LPV instrument approach procedures in the United States. These published procedures are shown on the LPV or LP line of minima on GPS/RNAV approach charts. Even though the procedures are published per runway, the prediction tool assumes that WAAS availability is the same for an entire airport.

The predicted WAAS service is available to the public on the internet. The results shown on the website are actually the combination of two tools. The first is the baseline prediction tool. This tool relies on the daily repeatability of the GPS constellation. Since the GPS constellation is repeatable day to day, WAAS performance is also repeatable. This baseline prediction tool accounts for predicted WAAS performance for the vast majority of the time. The second tool is the geometric prediction tool. The geometric tool simulates the WAAS algorithms. The website shows the results

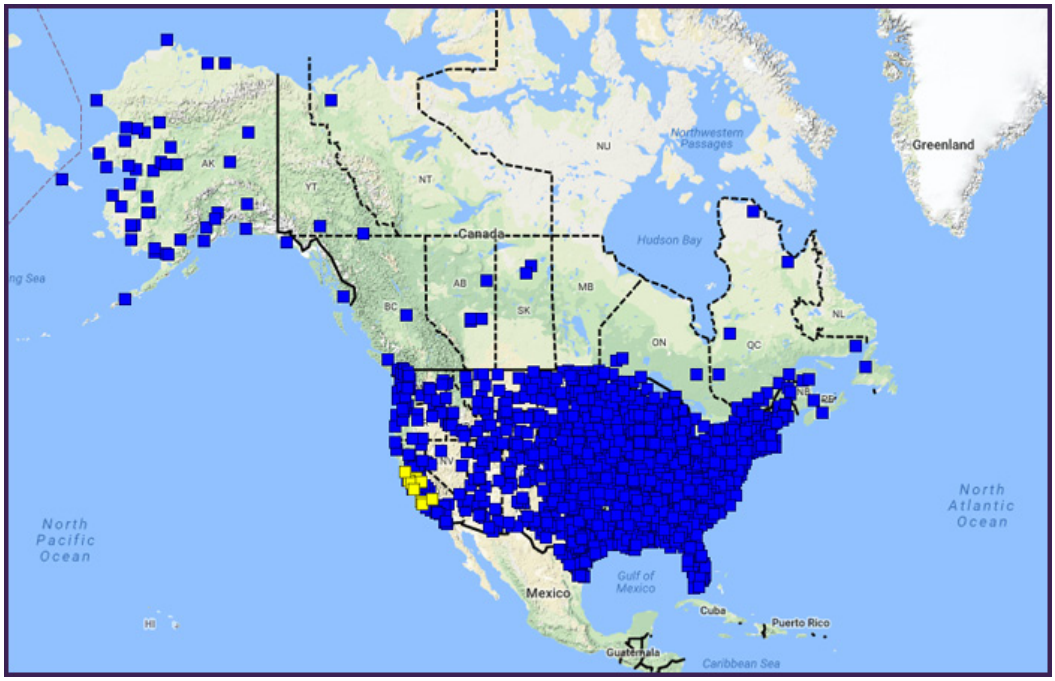


Figure 1. WAAS Predicted Airport Availability for November 29, 2017

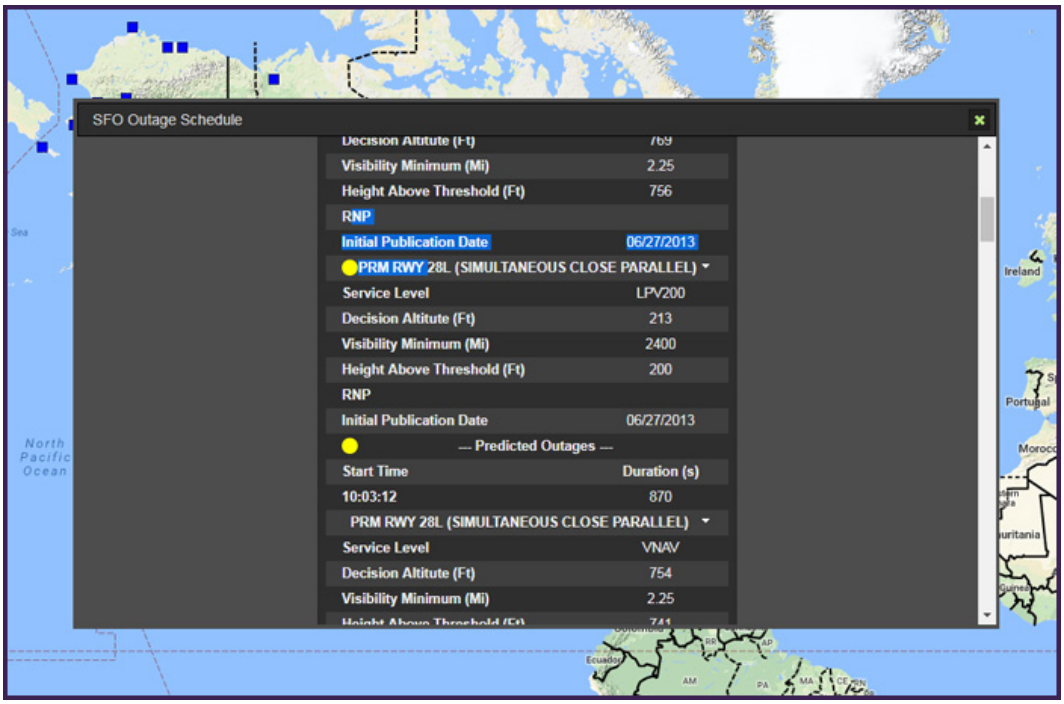


Figure 2. San Francisco Airport (SFO) Predicted Outage on November 29, 2017

from the geometric tool when there is a change in the configuration of WAAS. For example, a change in configuration could be a GPS satellite unavailable due to maintenance or a WAAS reference station is taken out of service for an upgrade. For the end user, whether the prediction came from the baseline tool or the geometric tool is transparent.

When visiting the website (http://www.nstb.tc.faa.gov/AirportSchedules/) the user is shown a familiar, interactive Google Maps display. The user is presented with the predicted WAAS performance at airports for a user specified date. The date is entered by the user in the upper left corner of the display. A user can also view results for a selected airport by using the search bar at the top of the display. For example, Figure 1 shows the predicted WAAS availability on November 29, 2017. The boxes in the figure depict airports with a GPS/RNAV LPV or LP published approach. The blue boxes mean no outages are predicted and yellow boxes mean at least one outage is predicted for that airport. A user can click on one of these boxes to get more information. Figure 2 illustrates the pop up window that appears when San Francisco Airport (SFO) is selected. The text in the window shows there is a predicted outage for Runway 28L beginning at 10:03:12 GMT and lasting for 870 seconds.

The WAAS Test Team continuously validates the prediction tool. The validation is documented in a monthly report. As a first step in the early development of the tool, the WAAS Test Team determined the accuracy of the tool's predictions after an event occurred. That is, if there was a planned GPS satellite outage, the tool would be run after that outage occurred with the exact times that the GPS satellite was not available. This approach provided a view of how well the prediction tool matched actual performance.

The method to validate is different for the baseline tool and the geometric tool. The baseline tool can only be validated during steady state conditions. A baseline day is established when the actual performance of WAAS is consistent over a time period or there are no changes in the WAAS configuration or GPS satellite maintenance actions. The baseline day represents the WAAS performance most of the time. The geometric tool, however, calculates WAAS performance when there is a change in the system. The WAAS algorithms are modeled in this tool. The geometric tool, therefore, is most useful

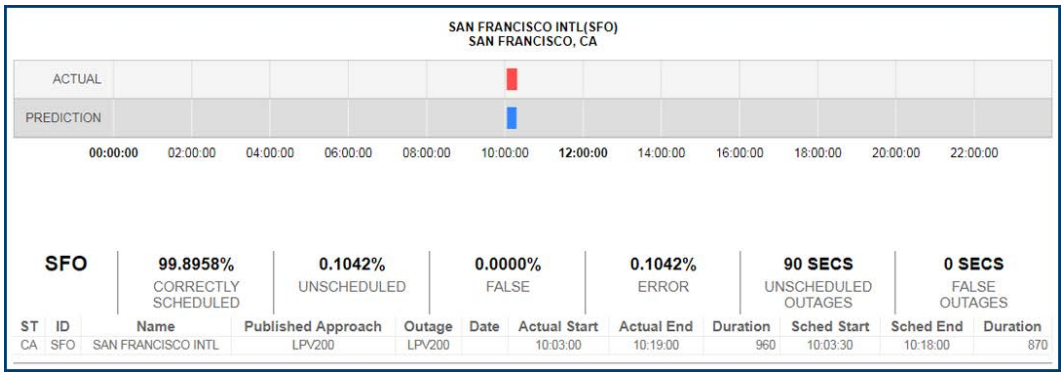


Figure 3. SFO Prediction Statistics for November 29, 2017

during these occurrences of disrupted WAAS configuration. Both tools are checked against actual performance to determine the accuracy of the prediction.

In using the above example, the accuracy of the WAAS prediction for November 29 is evaluated. Figure 3 shows how well the tool predicted actual WAAS performance at SFO. The top part of the figure shows the times for the predicted and the actual outage. Below that are the prediction statistics for SFO on November 29. From the stats, the predicted outage at SFO started 30 seconds after the actual outage occurred. Also, the end of the predicted outage was 60 seconds after the actual outage. That 90 second discrepancy between the predicted and actual outages resulted in about 0.1% of time that WAAS performance at SFO was incorrectly predicted at SFO on this day. Prediction accuracy of 99.9% or better is typical of the tool's performance. This type of validation is reported for each outage, either predicted or actual.

Predicting WAAS performance is utilized in several ways. FAA WAAS operations uses the prediction results to assist in planning maintenance and upgrades to WAAS. Also, the WAAS Test Team uses to tool to better understand how changes in WAAS configuration affects WAAS performance. In the future the WAAS prediction tool may be used to generate Notices to Airmen (NOTAM) to alert users of reduced WAAS availability.

The WAAS prediction tool continues to be refined. Regular examination of the accuracy of the tool assists in keeping the tool robust. Moving forward, the WAAS prediction tool will have many uses in support of WAAS service.
- Bill Wanner, FAA ANG/WJHTC

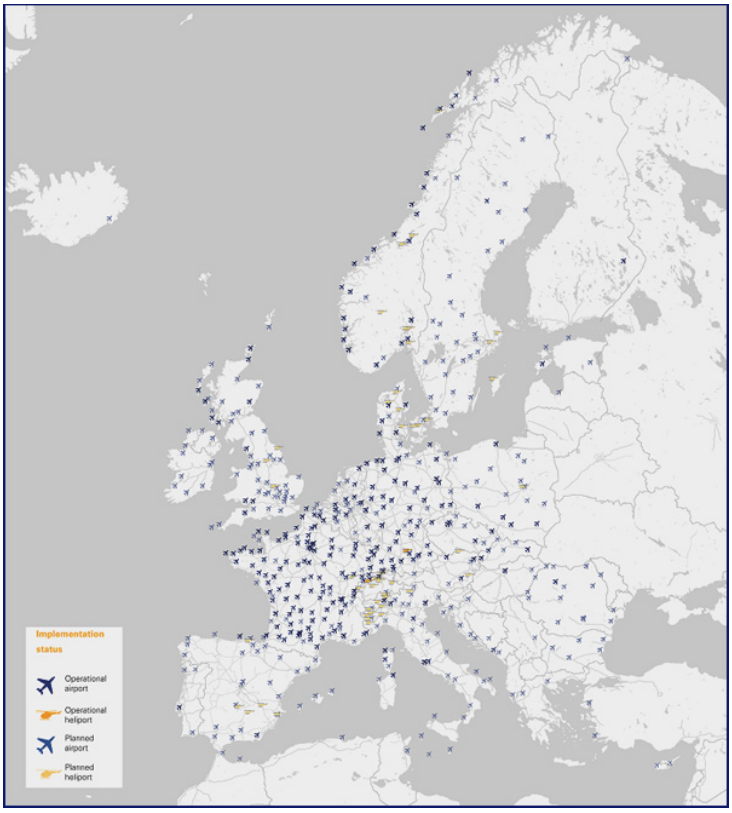
The Future with WAAS Dual Frequency Operations

WAAS Dual Frequency Operations (DFO) will improve the availability and continuity of the current instrument approach service in the continental US, Alaska, Canada and Mexico. WAAS DFO can also support an expanded service area for WAAS enabled instrument approaches to include Hawaii and Central America. WAAS DFO will provide additional resiliency against interference to the GPS L1 frequency for the WAAS Dual Frequency user. The FAA is currently in the process of determining the associated architecture of WAAS DFO. As WAAS DFO capabilities are dependent on GPS Modernization efforts currently underway, the FAA is assessing the ability to provide an Initial Operational Capability for the Dual Frequency SBAS services starting no earlier than 2023.

- Ranjeet Shetty and Joseph E. Dennis, FAA AJM-32/NAVTAC

European airlines grow appetite for EGNOS

Reprint from Airliner World, October 2017



European airlines are quickly upgrading their fleets to catch up with the rapid proliferation of the so called LPV approach procedures (Localizer Performance with Vertical guidance), which are now available at 214 airports across Europe as of August 2017. Since the EGNOS Safety of Life service declaration in 2011, an increasing number of procedures, which today account for a total of 371, has been relying on this technology to provide alternative means to ILS CAT-I approaches. Contrary to ILS, LPVs do not rely on any ground infrastructure at the aerodrome, which constitutes a significant advantage to medium size airports that cannot afford the installation or maintenance of these landing systems. LPVs represent also a great backup during ILS disruptions and a cost effective solution for secondary runway ends which are not served by precision approaches.

For these and other reasons, the implementation plans announced by the different European national air navigation service providers (ANSPs) estimate a total of nearly a thousand LPV procedures (APV-I and LPV200) by the end of 2020 (see map[1]). By then, according to a recent study by ESSP (the EGNOS Service Provider), 78% of all IATA flights in Europe will land at destinations with EGNOS-based procedures.

Beside these voluntary ANSP initiatives, the PBN Implementation in the European Air Traffic Management Network regulation to be released by EC in the coming months, complementing the Pilot Common Project (PCP), will request the publication of LPV procedures to all instrument runway ends not served by a precision approach by (tentatively) 2020, and to those served by precision approaches by 2024.

Given this steep trend in LPV publications, the upcoming regulation and the ILS rationalisation plans, like that already announced by France (30 ILSs removed to date), European operators

are now taking into serious consideration this technology that is finally becoming available at their network of destinations.

This interest is reflected in the way airlines are increasingly ordering LPV (SBAS) functionality options for their new deliveries (forward-fits) - by means of Service Bulletins - or are upgrading their existing non-SBAS-capable aircraft by means of Supplemental Type Certificates (retrofits).

Some of the pioneer European commercial airlines making use of LPVs on their daily operations are AirBaltic, Air Transport International, Aurigny Air Services, Hebrideanair, International Jet Management and Swiss International Airlines.

Work is in progress for many other airlines, such as AirNostrum, CityJet, Croatia Airlines, EasyJet, Eastern Airways, Finnair, HOP!, Loganair¸ Skybus, NextJet and Widerøe, who are either waiting for the delivery of their SBAS capable orders, or in the process of certification of their existing fleets, or training their crew as a final step before entering into LPV operations. In addition, many more operators are seriously evaluating an upgrade.

Amongst business operators, whose fleets show higher penetration of EGNOS-ready boxes than commercial airlines, the following are already benefiting from the use of these procedures: Air Alsie, AstonJet, CAT Aviation, Flying Group, GlobeAir, International Jet Management, iXAir, Jet Aviation Business Jets, NetJets Europe, Speedwings Executive Jets, TAG Aviation and VistaJet Ltd.

The operators' demand of LPV capabilities has urged aircraft manufacturers to offer solutions for both new and legacy aircraft. While some manufacturers are offering SBAS by default on the flagship models as it is the case for Bombardier CSeries, others offer it through Service Bulletin options (forward-fit) that can be activated prior to the delivery of the aircraft or while in service. This is the case, for instance, of Airbus A350, ATR 42-600 and 72-600, Bombardier CRJ, Twin Otter and Dash-8 families or Embraer E-Jet and ERJ models.

Additionally, operators have the chance to upgrade their fleets via Supplemental Type Certificates that can be installed by MROs. For the latter case, there is a large number of options available covering legacy aircraft like Airbus A300, ATR 42&72, BAE Avro 146,

Beechcraft 1900, Boeing 737, Bombardier Dash-8 and CRJ, Fokker 50, L-410 Turbolet or SAAB 340 & 2000 amongst others.

To confirm the current trends, Airbus has been selected for EC funding to enable SBAS on their future A320neo fleet[2], and Sukhoi has announced that they will certify their future SSJ100SV models for LPVs too. Rumours have it that Boeing might also be planning to include the capability for their B737NG, B787, B777MAX and B777X models by around 2020, although this has not been officially confirmed.

All these SBAS solutions make use of a wide variety of equipment currently available in the market from different manufacturers. Some examples are Rockwell Collins GPS-4000S and GLU-2100, Universal UNS-1Ew/-1Lw/-1Fw, Honeywell KGS200 and NGFMS, Esterline CMA 5024 or Thales Topstar 200. Additionally, all new Garmin products fitted on business or general aviation aircraft are SBAS capable.

Apart from offering lower Decision Height minima (200ft) and therefore better accessibility in conditions that would otherwise disrupt operations, LPVs provide several other benefits when compared to conventional approaches. For instance, since they increase the pilot's situational awareness and are not impacted by temperature and pressure conditions, LPVs increase safety and reduce the risk of controlled flight into terrain (CFIT) caused by pressure fluctuations or QNH miss-settings. Furthermore, they provide much more stabilised approaches than ILS and elude the possibility of capturing secondary lobes.

Until very recently (last year), AOC holders had to apply for a specific approval (SPA) to their competent authority for the majority of PBN specifications, including RNP APCH to LPV minima. Luckily, the European Commission introduced in 2016 the necessary changes to Air Crew Regulations so as to introduce PBN privileges to all Instrument Rating licenses, incorporating PBN in pilots' regular training and checking requirements. Besides, PBN was also incorporated to Air Operations Regulations as standard procedures for authorities and operators.

Over the past few years, both ANSPs and airlines have been able to subsidise part of their costs for implementing LPV procedures and retrofitting their fleets thanks to several European funding initiatives. For instance, the European GNSS Agency (GSA), who made available €12M in total in 2014 and 2015, has recently announced a third Call for Proposals in their EGNOS Annual 2017 Grants Plan[3] by the end of this year. The Call will cover also the development of new STC or SB solutions. If you are from an OEM, DOA, MRO or an airline…, that is an opportunity not to miss.

To find out more about how GSA and ESSP can support you in the implementation of EGNOS write to EGNOS-adoption@essp-sas.eu or visit https://egnos-user-support.essp-sas.eu

[1] https://egnos-user-support.essp-sas.eu/new_egnos_ops/content/lpv-procedures-map
[2] https://ec.europa.eu/transport/sites/transport/files/2016-cef-call-selected-projects.pdf
[3] https://www.gsa.europa.eu/sites/default/files/egnos_annual_2017_grants_plan_0.pdf

Your WAAS Story

. . . We're collecting testimonials about the benefits of Wide Area Augmentation System (WAAS) navigation from users. If you are a pilot, passenger, airport manager, controller, dispatcher, airline employee, or are involved in aviation in any capacity - whether you fly fixed-wing or vertical flight aircraft - we want to hear from you! Please send your stories and contact information to Amy Trevisan at: amy.ctr.trevisan@faa.gov

The following appeared in the March/April 2017 edition of the FAA Safety Briefing

Top 10 Things You Need to Know about ADS-B

Quick Tips and Information for GA Aircraft

With the fast approaching January 1, 2020 deadline to equip with ADS-B Out, pilots and owners want to learn more. Here are 10 things you need to know.

1. ADS-B Out is Mandated, Not ADS-B In

Only ADS-B Out is mandated, and only within certain airspace. Starting January 1, 2020, you must be equipped with ADS-B Out to fly in the airspace where a Mode C transponder is required today. ADS-B Out greatly improves your visibility to other aircraft by broadcasting your aircraft's position to other aircraft equipped with ADS-B In and to air traffic control (ATC).

Go to www.faa.gov/nextgen/equipadsb/airspace to find the airspace where ADS-B will be required near you. For more information on the mandate, see 14 CFR section 91.225 at http://go.usa.gov/x97sm and section 91.227 at http://go.usa.gov/x97sG.

You can also integrate ADS-B Out with ADS-B In avionics and displays. ADS-B In equipage is not required by the mandate, but it's a great addition to your situational awareness arsenal. ADS-B In can receive two types of free broadcast services — one for traffic information services (TIS-B), and another for flight information services (FIS-B).

The traffic picture displayed in your cockpit includes position information reported by other aircraft on ADS-B Out, as well as traffic information relayed from the FAA ground system (TIS-B).

In addition, you can benefit from graphical weather via FIS-B. FIS-B also broadcasts text-based advisories and aeronautical information such as Notices to Airmen, Temporary Flight Restrictions, pilot reports, and the status of Special Use Airspace. These features are only available via broadcasts on 978Mhz.

2. You Are Required to Operate Your ADS-B Out Transmitter at All Times

All ADS-B equipped aircraft are required to operate their ADS-B Out transmitter at all times including while on the surface of the airport — 14 CFR section 91.225(f).

Why? ADS-B Out works by regularly broadcasting position, velocity, and identification information to ATC, and other aircraft, to improve situational awareness at all times — on the ground and in the air. Increasingly, air traffic systems and ADS-B In products are being developed with alerting logic that depends on your ADS-B Out broadcast.

3. Portable ADS-B Out Units Are Not An Option

Portable ADS-B Out avionics (also known as "suitcase" units) are not an approved option for ADS-B Out.

Here's why. First, unlike installed equipment where antennas are appropriately positioned — the GPS antenna sits atop your aircraft, and the ADS-B antenna sits on the bottom —

portable units use a suction-cup antenna on the window or the glare shield of the plane. That's where it needs to be to get a usable GPS signal, but that position puts it in a prime spot to obstruct your view, especially if you're flying VFR.

Additionally, the portable system wiring potentially hampers controls and instruments and, if the antenna is not in just the right place, the signal suffers. In that case, ATC and other aircraft with ADS-B In can't see you.

Second, portables can transfer from aircraft to aircraft. That sounds like a great idea at first, but that's where mistakes can become an issue. On a portable, you have to input your aircraft's N-number — correctly. If you're off by just one digit, then the ID in your flight plan won't match up with the ID transmitted by your portable unit. A high number of call sign mismatch incidents happen for this very reason. To learn more, read "What's In a Name?" in this issue of FAA Safety Briefing.

Portable units are acceptable for use with your tablet only for the ADS-B In (ADS-B receiver) feature.

4. Uncertified Equipment? Check Your Airworthiness Certificate

You may only install an uncertified transmitter on amateur-built aircraft and light-sport aircraft with experimental airworthiness certificates if it meets the performance requirements of Technical Standard Order (TSO)-C166b or TSO-C154c.

For S-LSA owners, the ADS-B equipment must meet the performance requirements in TSO–C166b; or TSO–C154c, and the installation (i.e., alteration) must be performed in accordance with an applicable consensus standard and authorized by the aircraft's manufacturer.

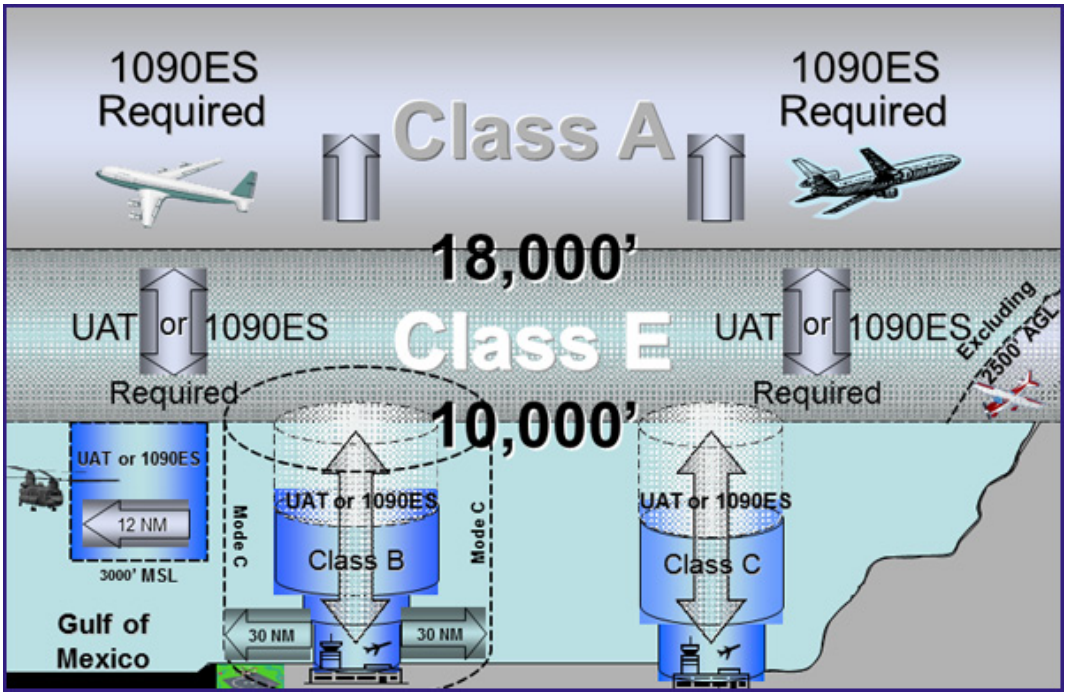
Additionally, you cannot install uncertified equipment, including uncertified transmitters on any aircraft with a standard airworthiness certificate. Uncertified ADS-B transmitters that do not meet the performance requirements of an ADS-B TSO will not be permitted to operate in airspace requiring ADS-B after January 1, 2020. ATC cannot use the data from transmitters that do not meet most of the performance requirements of 14 CFR section 91.227 — this means ATC cannot provide flight-following services or separation services to these aircraft.

For GPS equipment, you may install an uncertified GPS on amateur-built and light-sport aircraft with experimental airworthiness certificates. As stated above, uncertified equipment must meet the performance requirements of a GPS TSO.

Again, you cannot install uncertified equipment, including an uncertified GPS on aircraft with standard airworthiness certificates. Additionally, position sources that do not meet the performance of a GPS TSO will not comply with 14 CFR section 91.227 and will not be permitted to operate in airspace requiring ADS-B.

Amateur built aircraft and light-sport aircraft owners wishing to install an uncertified device that meets the performance requirements of TSO-C166b or TSO-C154c should ensure they obtain a letter from the equipment manufacturer, stating the device meets the performance requirements of either TSO-C166b or TSO-C154c.

You can search equipment options by manufacturer at http://go.usa.gov/x9bqW. More on this topic will be covered in future issues of FAA Safety Briefing. The bottom line is that the equipment option you choose must meet the performance requirements, and it must function properly!



5. Always Keep Your ADS-B Installation Instructions

Here's a quick tip. Always keep the installation instructions from the supplier, including the statement of compliance, in your aircraft records just in case you have any service problems.

6. You May Not Have To Buy a New Position Source Suitable for ADS-B

Avionics vendors offer reasonably-priced, built-in approved position sources, such as WAAS GPS receivers, and package them with ADS-B transmitters.

7. Make Sure Your ADS-B Equipment and GPS Equipment is an Approved Pairing

Any GPS receiver used as an ADS-B position source must be an "approved pairing" with the ADS-B transmitter. A GPS receiver must be compatible with the installed ADS-B transmitter. Go to https://www.faa.gov/nextgen/equipadsb/installation/equipment/for a list of certified equipment and pairings.

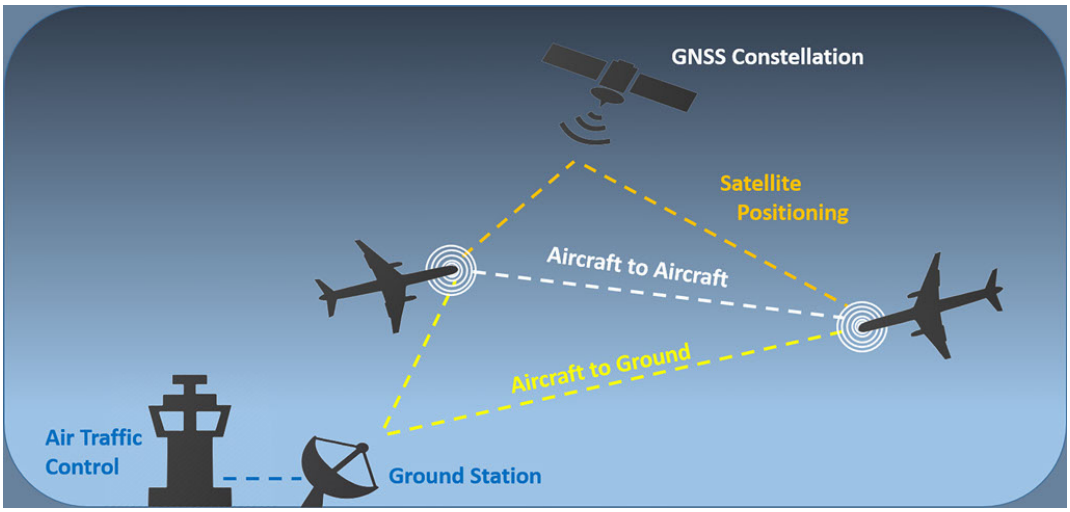
Mixing and matching GPS receivers with ADS-B transmitters in the field (accomplished via field approval) is not permitted unless the equipment was shown to be compatible via a previous certification effort with the FAA (for example, a Supplemental Type Certificate).

There are many options, but only certain combinations of GPS receivers and ADS-B transmitters function properly. Contact the equipment manufacturer if you are not sure which GPS receivers are approved for your ADS-B system.

8. The Airspace You Fly Reveals the Type of Equipment You Need

If you're flying in Class A airspace, you will need a 1090 megahertz extended squitter (ES) transmitter. You will also need a 1090ES ADS-B Out transmitter if you operate outside the United States in airspace where ADS-B is required.

Always flying below Class A, and not internationally where ADS-B is required? Then you have a choice between a 1090ES or a Universal Access Transceiver (UAT) transmitter.



The majority of Class E airspace is outside of ADS-B required airspace. In particular, airspace that starts at 700 / 1,200 feet above the surface up to 10,000 feet mean sea level (MSL), except from the Gulf of Mexico shoreline out to 12 nautical miles offshore. You can still be above 10,000 MSL, but below 2,500 above ground level (AGL) and not be required to have ADS-B.

For a detailed look at the ADS-B requirements per airspace, go to www.faa.gov/nextgen/equipadsb/airspace/requirements.

9. The ADS-B Out Mandate Applies to Foreign Operators

The United States' ADS-B-Out mandate will affect foreign aircraft operators. Starting January 1, 2020, all aircraft, including foreign-registered aircraft that operate in, or fly through the United States, must be equipped with ADS-B Out to operate in ADS-B required airspace in the United States. The ADS-B Out equipment must comply with the performance requirements found in 14 CFR sections 91.225 and 91.227.

10. Beat the Rush and Install ADS-B Out Now

As we have noted in other articles, 2020 sounds like a long way off. From a repair shop's point of view, though, 2020 is just around the corner. As we draw closer to the deadline, avionics shops may become inundated with appointments from owners who waited until the last minute. You may be unable to get a service date before the deadline, and you will not be allowed to fly in ADS-B required airspace until your aircraft is ADS-B Out equipped.

GBAS Facts

The ground inspection for the Block I at Newark International Airport was completed on November 16 with no issues.

Did You Know . . .

The Federal Aviation Administration (FAA) Wide Area Augmentation System (WAAS) was commissioned in 2003. To date, there are over 4,500 Area Navigation (RNAV) Global Positioning System (GPS) approach procedures to Localizer Performance with Vertical (LPV) & Localizer Performance (LP) minima. The implication here is that aircraft equipped with WAAS can access over 4,500 runway ends in poor weather conditions to minimums as low as 200 feet. There are over twice as many RNAV (GPS) approach procedures with LPV/LP line of minima as there are Instrument Landing System (ILS) glide slopes in the U.S. National Airspace System[1]. This is great news for WAAS and our stakeholders. However, after researching the internet and reading several third-party sites on the subject of WAAS there still seems to be significant ambiguity regarding WAAS and the capabilities it affords. The objective of this series of Q&A's is to provide some clarification for some of the noted and recurring misconceptions regarding WAAS and enhance situational awareness.

Our second set of questions in the series:
Q1 – *Is a WAAS LPV a precision approach?*
A1 – **No.** The Aeronautical Information Manual (AIM), section 1-1-18. B1, stipulates that an LPV does not meet the ICAO Annex 10 requirements to be considered a precision approach. The LPV is not a precision approach and is referred to as Approach with Vertical Guidance defined in ICAO Annex 6. LPV approaches take advantage of the refined accuracy of WAAS lateral and vertical guidance to provide an approach very similar to a Category I ILS flown to a Decision Altitude (DA)[1] .
Q2 – *What is the horizontal and vertical accuracy provided by WAAS?*
A2 – WAAS accuracy as reported by FAA[2,3].

WAAS accuracy

Accuracy	GPS Accuracy Requirements (as specified in the GPS Performance Standard)	GPS Actual Performance*	WAAS LPV-200 Accuracy Requirements (as specified in the WAAS Performance Standard)	WAAS LPV-200 Actual Performance*
Horizontal 95%	36 m	2.9 m	16 m	0.7 m
Vertical 95%	77 m	*4.3 m	4 m	1.2 m

**GPS and WAAS performance is monitored and measured by the FAA WAAS Test Team. Quarterly, Performance Analysis Reports for both GPS and WAAS are produced and made available on FAA WAAS Test Team website.*

[1]Aeronautical Information Manual (AIM), 1-1-30, 4/27/2017
[2]www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/waas/benefits/
[3]www.nstb.tc.faa.gov

- Steve Mulloy, FAA AJM-32/NAVTAC

The SatNav News is produced by the Navigation Programs AJM-32 branch of the Federal Aviation Administration (FAA). This newsletter provides information on the Global Positioning System (GPS), the Wide Area Augmentation System (WAAS) and the Ground Based Augmentation System (GBAS).

Satellite Navigation
Approach Procedures

WAAS LPVs

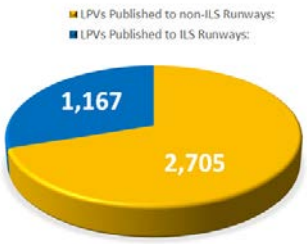
The table to the right reflects the continuing growth of satellite-based approach procedures. For more detailed information about satellite-based instrument approach procedures, please visit our GPS/WAAS Approach Procedures web page. *http://www.faa.gov/about/office_org/ headquarters_offices/ato/service_units/techops/navservices/gnss/approaches/index.cfm*

Satellite-based Approach Procedures

RNAV (GPS) Approaches	ILS Runways	Non-ILS Runways	Total
LPV Line of Minima	1,167	2,705	**3,872**
<250' Decision Altitude			*1,030*
Exactly 200' Decision Altitude			*983*
LP Line of Minima	4	651	**655**
LNAV Line of Minima	1,209	4,795	**6,004**
LNAV/VNAV Line of Minima	1,143	2,613	**3,756**
GPS Stand-Alone Procedures	1	58	**59**
GLS Approach	11		**11**

(Data as of December 7, 2017)

LPV UPDATE
3,872 TOTAL LPV'S PUBLISHED TO DATE



LP UPDATE
655 TOTAL LP'S PUBLISHED TO DATE

EGNOS LPVs

The number of LPVs in Europe is also growing. The table to the right shows LPV procedures in Europe as of October 12, 2017, as included in the EGNOS Bulletin Quarter 3 (Source: EGNOS Bulletin, Issue 24 Q3 2017)

Follow this link to the most recent EGNOS Bulletin Issue 24 Q3 2017: *http://egnos-user-support.essp-sas.eu/new_egnos_ops/content/quarterly-bulletin*

Country	Airports – SBAS APV procedures	# SBAS APV Procedures
Austria	2	2
Belgium	4	10
Croatia	1	1
Czech Republic	4	8
Denmark	4	8
Estonia	1	2
Finland	1	2
France	89	141
Germany	22	35
Guernsey	1	2
Hungary	0	0
Ireland	1	1
Italy	10	20
Netherlands	2	3
Norway	16	24
Poland	5	9
Portugal	2	3
Romania	1	2
Slovak Republic	2	4
Spain	2	4
Sweden	1	1
Switzerland	7	9
United Kingdom	14	31
Total	**191**	**322**

Canadian WAAS LPVs

Numbers provided by
NAV CANADA
as of December 7, 2017