SatNavNews

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

The Sum of All Performance-Based Navigation Procedures

by David Hughes, FAA NextGen Outreach and Reporting
Reprint from Avionics News, July 2017

NextGen is on track and delivering benefits to aircraft operators. A prime example of how the FAA's modernization program is transforming the National Airspace System (NAS) is a nationwide network of more than 9,000 Performance Based Navigation (PBN) procedures and routes.

PBN benefits for general aviation aircraft operators include improved access to many general aviation airports during reduced visibility.

PBN is an advanced, satellite-enabled form of air navigation that creates precise 3-D flight paths. If an aircraft relies on satellite positioning with GPS or Wide Area Augmentation System (WAAS), its avionics can navigate a flight path with much greater precision and accuracy than with legacy navigational systems. GPS and its augmentation systems constitute what is known internationally as a global navigation satellite system (GNSS).

PBN procedures require various avionics capabilities depending on the level of navigation precision involved. Because of mixed equipage, not all aircraft can fly the most-demanding types of PBN procedures. New aircraft usually have the latest avionics while older aircraft have a mix of avionics of various ages and capabilities. Replacing aging equipment can prove too expensive for some aircraft operators and may lead to an aircraft being retired. In other cases, an aircraft's existing equipment may be adequate for the types of flight operations planned.

HIGHLIGHTS

- Plans to create a PBN-centric NAS — one of NextGen's primary goals — are outlined in the PBN NAS Navigation Strategy 2016, which details objectives from 2020–2030 and beyond.
- The FAA has already published more than 9,000 PBN procedures and routes.
- PBN procedures and routes save time and fuel while reducing emissions and government spending on ground-based navaids

PBN consists of:

- RNAV (GPS) approaches: The FAA has published more than 6,500 of these procedures for aircraft equipped primarily with GPS or GPS enhanced by WAAS. RNAV (GPS) approaches permit aircraft with the required navigation performance to operate on any desired course within the coverage of the navigation signals in use. Tens of thousands of general aviation aircraft equipped with WAAS use more than 3,700 Localizer Performance with Vertical Guidance (LPV) approach procedures at more than 1,800 airports and more than 600 Localizer Performance approach procedures (without vertical guidance) at 470 airports.

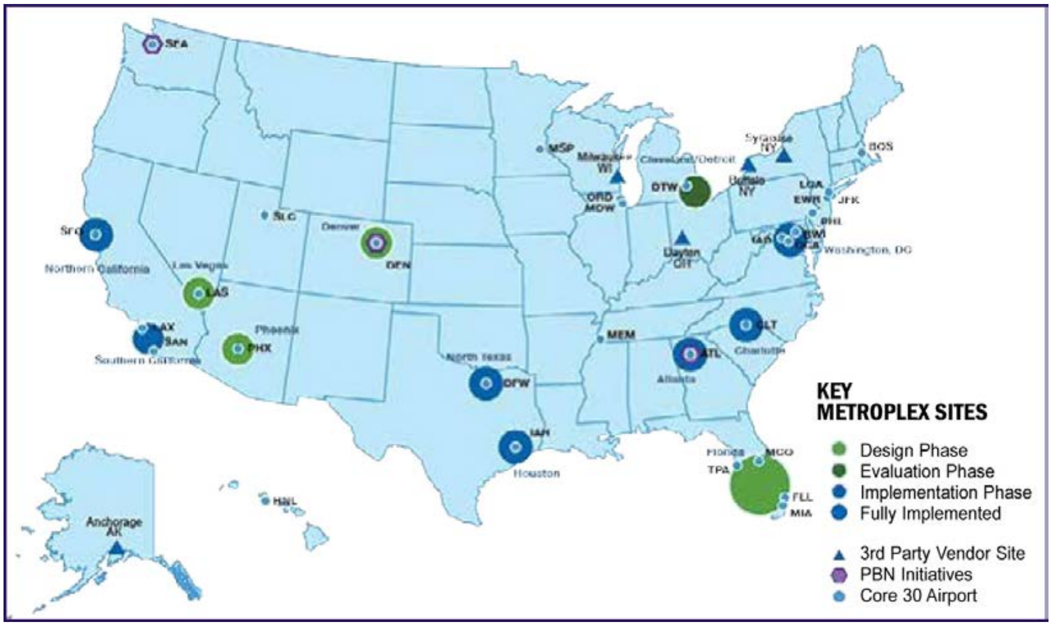
- LPV provides minimums as a low as 200 feet above the ground before a pilot has to see the runway to land, which is the same as a Category 1 (Cat 1) Instrument Landing System (ILS). LPVs serve more than 1,000 airports that do not have ILS. The FAA will seldom, if ever, install a new Cat 1 ILS, opting instead for PBN approach procedures.
- RNAV Required Navigation Performance (RNP) approaches: These highly accurate approach procedures enable aircraft equipped with self-monitoring avionics to operate safely near high terrain or in congested airspace. To fly these procedures, aircrews must be trained and FAA-authorized, and aircraft must be certified. Some RNP approaches enable aircraft to fly a curved path to a runway even when other aircraft are approaching to land on parallel runways. More than 390 of these approaches are available in the NAS.
- RNAV Standard Terminal Arrivals (STAR): RNAV STAR procedures can provide a continuous descent from cruise altitude using Optimized Profile Descents (OPD) to save fuel and reduce emissions and noise. The FAA has published more than 800 RNAV arrival procedures.
- RNAV Standard Instrument Departures (SID): RNAV SIDs provide fixed, precise paths for aircraft from takeoff to en route airspace with a minimum of level offs to reduce fuel consumption and noise. Standard routings simplify navigation tasks for pilots and controllers in all weather. More than 1,100 RNAV SIDs keep departing traffic well separated from arrival traffic.
- Q- and T-Routes: The FAA is replacing high- and low-altitude routes that rely on ground-based navigation aids (navaids) with RNAV routes for use by aircraft with RNAV capability. Q-Routes can be flown using positioning from either satellite signals or Distance Measuring Equipment (DME) in case of a GPS outage. Q-Routes are replacing many Jet routes in high-altitude airspace (18,000 to 45,000 feet). T-Routes can be flown only with GNSS and are replacing many Victor routes in airspace from 1,200 feet above the surface to 18,000 feet.

For an up to the moment summary of all currently published instrument flight procedures see the FAA's Instrument Flight Procedures (IFP) Inventory Summary page which is updated periodically at https://tinyurl.com/d9ue3pv. Also see the FAA's Satellite Navigation — GPS/WAAS Approaches page (also updated periodically) at https://tinyurl.com/zqeulj7.

The FAA also has designed a PBN route structure concept of operations to provide specified paths where needed and the capability for aircraft to fly direct from point-to-point where they are not needed. The straight paths possible with RNAV routes that do not have to zigzag from one ground-based navaid to the next reduce fuel consumption and aircraft exhaust emissions by shortening flight distance. One Washington Center sector that could fit only two Jet routes into its airspace has replaced them with four Q-Routes. Jet routes can only be located on a direct line between two ground-based navaids while Q-Routes can be located anywhere in the airspace as long as they are properly separated. With four Q-Routes instead of just two Jet routes, each of three major airports in the Washington, D.C., area now has its own feeder route, as does air traffic headed for New York airspace. The FAA has published more than 140 Q-Routes and more than 110 T-Routes.

PBN Today

One of the FAA's highest-priority PBN efforts focuses on 11 metroplexes — metropolitan areas where crowded airspace has to serve



Metroplex Locations (Current as of February 2017)

the needs of multiple airports. PBN departure, arrival, and approach procedures in these metroplex areas are already providing great benefits in congested terminal airspace.

The FAA has published many RNAV STAR procedures with OPD capability at metroplexes that enable aircraft to achieve greater fuel efficiency by flying closer to the airport before starting a continuous descent, which eliminates fuel-burning level offs. OPDs can be flown when available and when pilots are able to use them.

The FAA has worked closely with the NextGen Advisory Committee (NAC), a federal advisory committee composed of aviation stakeholders, to set implementation priorities. Through this collaboration, the FAA has completed PBN work in four metroplexes:

North Texas: 67 PBN procedures
- 32 RNAV STARs
- 29 RNAV SIDs
- Six RNP approaches

Washington, D.C.: 49 PBN procedures
- 24 RNAV STARs
- 25 RNAV SIDs

Houston: 46 PBN procedures
- 20 RNAV STARs
- 20 RNAV SIDs
- Six RNP approaches

Northern California: 44 PBN procedures
- 17 RNAV STARs
- 19 RNAV SIDs
- Eight Q-Routes

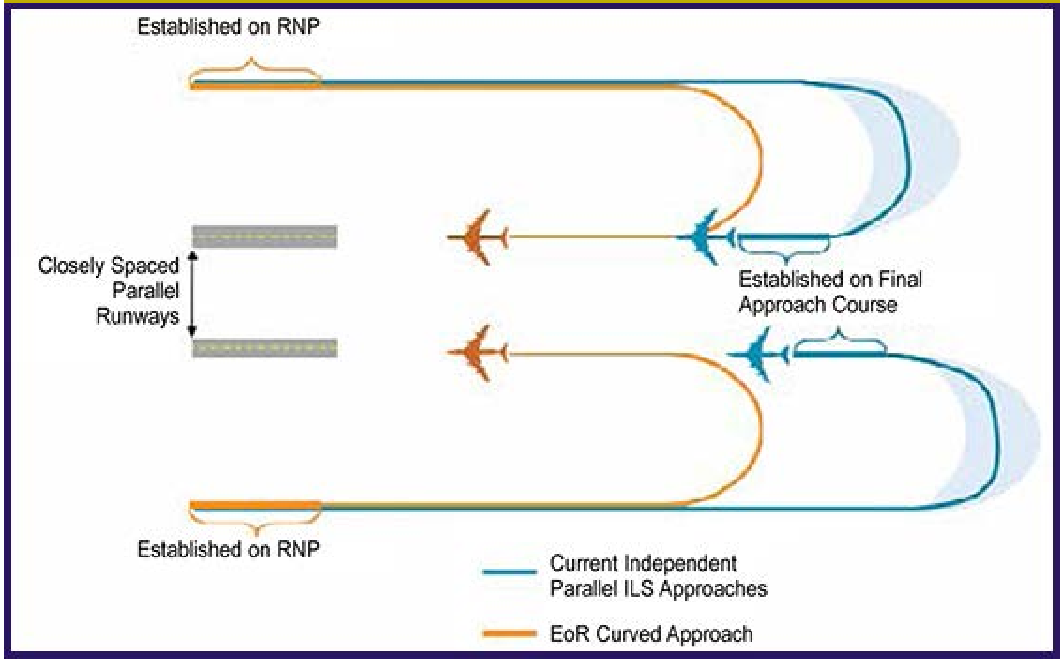
The FAA is preparing to publish 225 more PBN procedures in three more metroplexes, including:
- 126 at Southern California
- 68 at Atlanta
- 31 at Charlotte

In addition, Cleveland-Detroit is in the evaluation phase, while South Central Florida, Denver, and Las Vegas are in the design phase.

Denver is already using a network of RNAV STARs developed before it became a Metroplex site. These STARs have enabled RNAV (RNP), also known as RNP Authorization Required, approaches to runways since late 2013. For several years, the airport has averaged more than 1,000 RNP approaches per month.

Denver uses RNP approaches that provide aircraft flying opposite the direction of landing a new method for making a U-turn to line up to land. Before RNP, controllers monitored an aircraft on radar and gave pilots a series of headings as they turned to join other aircraft already lined up on a straight-in approach to the runway. Before an aircraft under radar

A new FAA Established on RNP rule allows controllers at Denver to instruct pilots to make a U-turn much closer to the runway (orange) than with legacy procedures (blue). The aircraft experiences all the benefits of flying a shorter path. *(Image courtesy of MITRE)*



contact could start to turn, however, controllers had to be sure it would remain separated 3 nautical miles (nm) laterally or 1,000 feet vertically from other aircraft. This led to aircraft flying as many as 20 nm away from the runway before a U-turn was possible.

Now, due to an Established on RNP (EoR) rule change by the FAA in 2015, an aircraft can be considered established on a precisely defined, curved approach procedure with the required separation from other aircraft before it begins its U-turn to the runway. The EoR technique has enabled controllers to use curved RNP approaches more often at Denver. EoR shortens the path each aircraft takes to the runway by about 6 nm in visual conditions. As a result, Southwest, United, and Frontier airlines save fuel every time they fly one of these curved approaches.

NAC priority areas are not the only places benefiting from PBN procedures. OPDs on STAR procedures also help large airports outside of the Metroplex program, such as Minneapolis-St. Paul. More than 100 PBN projects are underway for smaller airports with unique circumstances.

PBN Ahead

The FAA is creating a PBN-centric NAS, which has always been a primary goal of NextGen. The FAA outlined its plans in the PBN NAS Navigation Strategy 2016 , which details the agency's PBN objectives from 2020–2030 and beyond.

The FAA's overall objective is to use PBN throughout the NAS while employing the right type of procedure to meet the need in question. In some cases — as with metroplexes — this will include a highly structured, yet flexible, navigation pattern. The FAA recognizes the importance of involving all stakeholders — including airport operators and surrounding communities — in developing and deploying PBN procedures to ensure that community concerns are addressed. The agency is enhancing its community involvement during all phases of Metroplex and single-site PBN development, including going beyond the requirements of the National Environmental Policy Act.

In future deployments, the FAA will use a navigation service group concept to provide different scales of PBN operations for airports varying in size and levels of airspace complexity. For example, Group 1 will include the 15 busiest large hub airports in the United States. RNAV SIDs and STARs will be used at these airports to organize traffic flows, with legacy ground-based navaids used as a backup in case of a GPS outage. Groups 2 through 6 involve airports of decreasing size and varying degrees of airspace complexity. In general, airport navigation needs become less challenging in the higher group numbers. The FAA outlines the types of PBN procedures best suited for these different groups of airports.

Controllers will use new Time Based Flow Management tools to adjust the timing and sequence of aircraft arriving in the terminal area so they can smoothly execute PBN arrival and approach procedures.

The FAA's Aviation Safety Organization is developing ways to reduce runway separation requirements for EoR, which would make it possible to use the procedure in instrument meteorological conditions. It's also developing a new type of EoR that will qualify more aircraft to use it based on their existing avionics. This will help move the NAS away from inefficient radar vectors, which are still used to guide aircraft on thousands of approaches every day.

VOR ground-based navaids will remain as a navigation method for non-DME/DME aircraft during a GNSS disruption, not to create route structures. The VOR Minimum Operational Network (MON) implementation program will transition from a legacy network of more than 950 VORs to a MON of about 650 VORs by 2025. In July 2016, the FAA published a list in the Federal Register of VOR sites that may be shut down.

The FAA's planned continuous PBN improvements will create numerous benefits, including:

- Safe access to airspace near obstacles and terrain.Vertical guidance needed for more stable and safer approaches.
- Better segregation of traffic.
- Reduced divergence in departure paths.
- Increased efficiency in sequencing, spacing, and merging, making arrivals at the gate more predictable for airlines and their staff.
- Improved predictability to enable airlines to schedule the staffing of gates more effectively.
- Improved access to airports during low visibility, especially for general aviation.
- Reduced flight track distance.

For more information on other aspects of NextGen see the NextGen Update 2017 website at http://www.faa.gov/nextgen/update/

Satellite-Based Augmentation System (SBAS) Interoperability Working Group (IWG) Update

South Korea hosted the 32nd meeting of the SBAS IWG in Seoul. Participants in this meeting included the United States, Japan, Europe (including European Space Agency (ESA) and European GNSS Agency (GSA), and European Satellite Services Provider (ESSP), India, Russia, Korea, EGNOS-Africa Joint Program Office (JPO), Canada, and Australia.

In opening remarks, the co-chairs noted that with SBAS success, there is increased participation in the IWG. They acknowledged the gracious reception from the South Korean hosts and welcomed participation from Australia. The co-chairs suggested that a smaller sub-group be formed to address more technical aspects related to SBAS. This would permit SBAS providers to continue to exchange lessons-learned on SBAS deployment, obsolescence refurbishment, and expansion plans while enabling continued development of SBAS technology.

IWG continued to discuss the Dual Frequency Multiple Constellation (DFMC) SBAS. After IWG approved the DFMC SBAS Definition Document and Interface Control Document at IWG-31, IWG provided these documents the standards bodies as the starting point for the development of DFMC SBAS standards. IWG reviewed that both the International Civil Aviation Organization and EUROCAE are making in drafting DFMC SBAS standards. These bodies identified several questions related to the IWG concept baseline. IWG discussed a path forward to answer these questions. Both of these standards bodies are working to produce draft standards by the end of 2018.

During the course of the meeting, IWG reviewed status of current and developing SBAS systems. In particular, South Korea, Australia, Russia and EGNOS-Africa Joint Program Office provided updates on development of SBAS systems in their countries and regions. The Korean Aerospace Research Institute awarded two contracts for the procurement of the Korean Augmentation Satellite System (KASS) in 2016. Australia commenced a two-year SBAS demonstration that will include broadcast of demonstration SBAS signals on L1 and prototype DFMC SBAS signals on L5. Russia provided an update on the development of the System of Differential Correction and Monitoring. The EGNOS-Africa JPO provides coordination among African countries for the development of SBAS. The EGNOS Africa JPO has divided Africa into four Regional Economic Communities (RECs) and is considering how each of these RECs might enable the use of SBAS technology. One or more of these RECs might deploy an SBAS system. Depending on coordination, it might be possible to extend one or more SBAS systems to cover multiple RECs.

To find a copy of the latest SBAS Global Status Brief presented at the IWG, follow this link:
https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/library/briefings/

- Joseph Dennis, FAA AJM-32/NAVTAC

Participant's at the 32nd meeting of the SBAS IWG in Seoul, South Korea, June 7-9, 2017

The following appeared in the Delta News Network, an internal Delta publication

Delta Airlines has an Eye on Future Technologies

A321 Fleet Completes First GLS Approach In Newark

On Thursday, August 17, 2017 Delta flight 2343 landed in EWR on what appeared to be a routine flight from Atlanta. A water cannon salute and a PA by the captain were the only indications that this was the first revenue GLS approach by an A321 in North America. Delta's order of 132 A321's and the GLS receivers installed on those aircraft are part of a strategic effort to evaluate the potential benefits of technology and performance.

Delta Flight Operations has embarked on an initiative to ensure future flight deck capabilities are compatible with known regulatory changes, improved performance requirements and new and developing technologies.

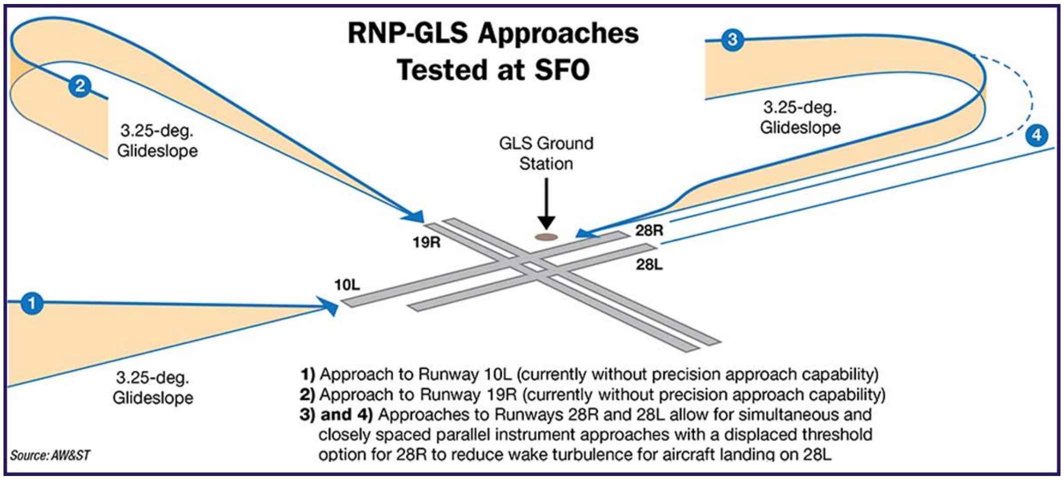
The goals of this initiative are to assure:

- We operate the safest aircraft in the air and that our pilots will have the best tools available
- Compliance with all government mandated equipage requirements
- Ability to participate in all airspace initiatives – worldwide
- System equipage that maximizes the crew's efficacy while reducing operational and training complexity

Delta continues to invest in comm/nav, avionics, hardware, EFB, and ETOPS technologies to assure unrestricted airspace access, network flexibility, increased schedule reliability, improved efficiency, and an overall reduced cost to operate.

Delta Captains Art Smith and Rich Kaynor Newark Liberty International Airport (EWR)

Ground Based Augmentation System (GBAS) is a technology that continues to show potential. Currently, the only airports Delta serves which have GBAS infrastructure are EWR and IAH. However, several airport authorities are exploring GBAS technology and Delta has partnered with SEA, SFO and the New York, New Jersey Port Authority to discover and refine GBAS benefits. Flight 2343 to EWR was part of this effort.



Delta's current GLS equipped fleets include A321, A350, and the 737. Procedurally, GLS approaches are flown very much like ILS approaches with the benefit of varying glide path angles and, where appropriate, varying touchdown points which provide flexibility not available in conventional ILS approaches. GLS will also eliminate bending localizer beams and false or mirror glideslopes. The resiliency of GBAS/GLS was demonstrated during winter storm Jonas. When the storm hit the New York area all 18 of the Port Authority's ILS platforms experienced service outages. The single GBAS at EWR provided precision approaches to GLS equipped aircraft throughout the storm.

A single GBAS unit provides up to 48 approaches at the host airport. This may result in multiple approaches to one runway. Approach design may allow greater wake turbulence separation, fuel and carbon emissions reduction, and precision approaches to runways that cannot be serviced with ILS approaches. When coupled with RNP capability and increased glideslope angles this technology will reduce noise exposure to communities.

Delta Air Lines, United Airlines, FAA, San Francisco International Airport, Jeppesen and Boeing participated in an RNP to GLS Advanced Concept Demonstration in SFO in August 2016. The GLS procedures flown in SFO are highlighted in the graphic above. These demonstration flights were successfully flown as part of the Company's efforts to explore promising technologies.

Advanced technologies require long lead times as development, investment, ground installation, and aircraft equipage must reach a level necessary for practical employment. While GLS equipage on A321, A350, and 737 is growing, Delta is looking for a level of airport GBAS equipage that will allow greater GLS approach availability. Airline participation in GLS development will help determine the operational feasibility of the concept and the viability of expanded deployment.

1800 RVR Alert. . .

On May 30, 2017 the FAA signed a waiver to update Order 8400.13D allowing LPVs and GBAS Landing System (GLS) to go down to 1800 RVR. In the absence of required lighting, the use of Flight Director (FD), Autopilot (AP), or HUD to Decision Altitude (DA) will be annotated with a chart note.

SatNav News Interview with a member of the "WAAS Operational Implementation Team"

Dave Khanoyan

(SatNav News) SN: *Thank you, Dave, for taking the time to chat with us, today.*
(Dave Khanoyan) DK: I assure you, it is my pleasure. Thank you for the opportunity to talk about my work with the Wide Area Augmentation System (WAAS) Operational Implementation Team (OIT).

SN: *How long have you been on the WAAS OIT…and would you mind telling us a little bit about your background, as well as the work that you do today?*
DK: Certainly. I have an Air Traffic Control background, four years with the U.S. Navy and 27 years with the Federal Aviation Administration (FAA) . I have worked with the WAAS program office since 2010. So, I have been involved in aviation safety now for close to 38 years. Our team consists of subject matter experts (SME's) in their particular field, such as professional airline pilot, helicopter pilot, Center air traffic controller, Tower air traffic controller, flight service specialist and flight dispatcher.

Many of us have a military background, as well. Without the combination of talents and expertise of these fine and upstanding individuals (I feel immense pressure to state this on the off chance that they may actually "stumble" upon this article), our accomplishments in enhancing the safety of the National Airspace System (NAS) thus far would have never been realized. I am eternally grateful for my teammate's dedication to duty and their service to our country.

SN: *What exactly does your work with the WAAS OIT entail?*
DK: We actually demonstrate the beneficial capabilities which are enabled by the WAAS GPS signal enhancement. Beneficial to flight crews, air traffic controllers, the flying public,

airports and aircraft owners, operators, as well as their shareholders.

On July 10, 2003, the WAAS signal was activated for general aviation, covering 95% of the United States, and portions of Alaska offering 350 feet (110 m) minimums. Today, the "minimums" are as low as 200 feet.

SN: *Dave, could you please discuss a project that you are presently working on?*

DK: One of many projects in the works is our partnership with the Maryland State Police Aviation Command (MSPAC) Emergency Medical Services (EMS) Helicopters. We are helping the Maryland State Police realize all of the benefits which the department's investment in WAAS technology will provide them.

MSPAC EMS is a fully-integrated medical transport company serving the state of Maryland. They operate 7 helicopter bases throughout Maryland. All MSPAC EMS helicopters are multi-engine airframes that provide an additional level of safety. The AugustaWestland-139 (AW139) helicopters that will be used in this initiative are equipped for flight under Instrument Flight Rules {IFR} conditions (similar to the scheduled airlines) and operate under Federal Air Regulations (FAR) Part 135.

MSPAC EMS has FAA approved Global Positioning System (GPS) instrument approaches to area hospitals throughout Maryland that support all-weather flight operations. These approaches permit MSPAC EMS to transport critical patients to the area's trauma centers and other hospitals offering specialized care during poor weather conditions.

Our partnership with the Maryland State Police shall:

- Demonstrate how WAAS approaches permit continued Emergency Medical Services operations during poor weather conditions
- Demonstrate advanced approach procedures, low altitude IFR infrastructure and quantify benefits associated with WAAS
- Illustrate Reduced Flight Time
- Establish a network of safe, environmentally friendly/efficient WAAS-enabled routes connecting trauma centers, hospitals, etc.

SN: *I understand that you volunteered to "staff" the FAA's Flight Simulator during "Tech Center Tuesday", which is held mid-May each year. How much fun was THAT?*

DK: It really WAS a whole lot of fun for me. "Tech Center Tuesday" is actually a misnomer. In reality, it's a four-day event.

Beginning on the Friday before Mother's Day and continuing through Wednesday.

I must say, my "volunteering" to go to the FAA's Technical Center, located in Atlantic City, New Jersey, is a completely selfish act on my part.

Whenever I get the opportunity to tour their facilities and observe the advances which are occurring in the field of aviation, I jump at the chance! In addition, I get a kick out of introducing people to the "magical world" of aviation…..ESPECIALLY children.

Opening Day for the Tech Center event was Friday, as I previously mentioned. The day was reserved for the families of the Tech Center workforce; so naturally, there were quite a few kids in attendance.

Being a big kid, myself, I could totally relate to them. I became "Grampa Dave" to the children and fed off of their excitement when they approached my "video game".

The Flight Simulator is based upon an SR22 platform (Cirrus), complete with parachute. We generally set up our simulator at Aviation Conventions/Events in order to demonstrate to those who wander toward our "booth" the ease and simplicity of flying a WAAS approach {RNAV (GPS) Approach} flown to the lowest minimums available [currently 200 Feet Above the Ground (AGL].

Our interactions with the attendees usually results in confirming that "they don't know what they don't know." Let me give you an analogy:

I have a cell phone and I am also a bit technologically-challenged. I don't realize all of the amazing things that my cell phone is capable of doing. That is…UNTIL…one of my children or grandchildren explains to me that, "Hey, Grampa, did you know that there's an APP for that?"

Well, it's the same thing with WAAS avionics. An aircraft owner invests in WAAS avionics…..he/she may have purchased the equipment simply to comply with the FAA's Automatic Dependent Surveillance – Broadcast (ADS–B) OUT mandate, which takes effect on January 1st in the year 2020. Unbeknownst to the aircraft owner, if they unlocked the capability for LPV minimums and Radius-to-Fix (RF) Turn capability, instead of simply using the WAAS sensor as a navigational source, they would benefit from their investment ten-fold.

With the flight simulator, we are able to demonstrate ALL of the benefits of WAAS, from situational awareness to flying the "auto-piloted" simulator to "minimums". Safety of flight is enhanced; pilot workload is decreased; and peace of mind is achieved.

On Monday, the Tech Center event continued, hosting the STEM Education Coalition (Science, Technology, Engineering, and Mathematics). Monday morning was reserved for High School Students, while the afternoon session was reserved for College Students.

Tech Center Tuesday was the final day of the event, reserved for the ATCA conference attendees. I was amazed at the interest exhibited each day.

I had much needed and greatly appreciated help "staffing" the flight simulator, throughout the 4-day event. Test Pilot Dan Dellmyer was a pleasure to work with. I couldn't have "survived" without him.

SN: *Dave, I realize that you "do what you do" in order to provide "tools" for pilots and air traffic controllers to work smarter…not harder.*

Many of our readers have submitted testimonials about how WAAS-enabled vertically-guided approaches have helped them gain access to airports previously unavailable to them. They have all requested that we pass along their gratitude to you and your team.

DK: You're welcome…

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 is reprinted from GPS World at http://gpsworld.com

Last Galileo satellite leaves ESA Test Centre

By GPS World Staff
September 5, 2017

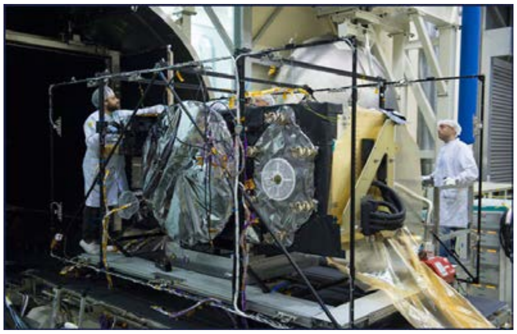
The last of 22 Galileo satellites has departed the European Space Agency's (ESA) Test Centre in the Netherlands. This concludes the single longest and largest scale test campaign in the establishment's history, ESA said.

Enclosed in its protective container, Galileo Full Operational Capability (FOC) Flight Model 21 (FM21) is seen departing ESA's ESTEC Test Centre on August 24

Cocooned in a protective container for its journey — equipped with air conditioning, temperature control and shock absorbers — the final Galileo satellite left the establishment by lorry on Aug. 24.

ESA's Test Centre at ESTEC in Noordwijk, the Netherlands, houses a collection of test equipment to simulate all aspects of spaceflight. It is operated for ESA by private company European Test Services (ETS) B.V.

In May 2013, the Test Centre began testing the first of 22 Galileo "Full Operational Capability" (FOC) satellites, having previously performed the same function for the very first Galileo "In-Orbit Validation" satellite under a separate contract.



A Galileo Full Operational Capability satellite being removed from the Phenix thermal vacuum chamber after a fortnight-long "hot and cold" vacuum test

The Galileo FOC satellites had their platforms built by OHB System AG in Germany, incorporating navigation payloads coming from Surrey Satellite Technology Ltd. in the United Kingdom. They then traveled on to ESTEC to be subjected to the equivalent vibration, acoustic noise, vacuum and temperature extremes that they will experience for real during their launch and orbit, plus testing of their radio systems.

With a steady stream of satellites coming off the production line, the challenge for the combined ETS and OHB team overseeing Galileo testing was to put them through all necessary tests on a rapid and efficient basis, while also keeping the Test Centre accessible to other European missions requiring its unique services.

A total of 14 FOC satellites have since joined the first four IOV satellites in orbit, forming an 18-strong constellation that began Initial Services to global users on Dec. 15, 2016. The next four FOC satellites are scheduled for launch on an Ariane on Dec. 5.

"For the first time in more than four years, there are no Galileo satellites in the Test Centre, but hopefully this will not be the end of our association with the programme," said Jörg Selle, managing director for ETS. "The contract for making the next eight Galileo satellites — known as Batch 3 — was also awarded to OHB last June, and ETS will be bidding for the contract to test these satellites too."

"The availability of the ETS facilities in ESTEC have substantially contributed to the programme," said Paul Verhoef, ESA director of the Galileo Programme and navigation-related activities. "We thank ETS for their professionalism and support over this extended period."

The final Galileo travelled back to OHB in Germany for some final refurbishment ahead of its launch together with another three satellites in December.

(Photos courtesy of the European Space Agency)

Europe's Galileo navigation satellites orbit 23,222 km above Earth to provide positioning, navigation and timing information all across the globe.

Did You Know . . .

The Federal Aviation Administration (FAA) Wide Area Augmentation System (WAAS) was commissioned in 2003. To date, there are 4,441 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 4,441 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 first set of questions in the series:

Q1 – *Is there a difference between the FAA's Wide Area Augmentation System (WAAS) and the Satellite Based Augmentation System (SBAS)?*

A1 – **No.** WAAS is a Satellite Based Augmentation System (SBAS) for North America that augments the GPS Standard Positioning Service (SPS) by broadcasting differential GPS (DGPS) correction messages from GEO satellites[2].

Q2 – *Since WAAS is the SBAS capability for the U.S., are there similar SBAS capabilities in other countries?*

A2 – **Yes.** The following is a list of countries that also have SBAS. Note that the nomenclature associated with the respective SBAS capabilities differs by country.

- European Geostationary Navigation Overlay Service (EGNOS) – Europe (covers the majority of the EU)
- MTSAT Satellite Based Augmentation Navigation System (MSAS) - Japan
- GPS-Aided GEO Augmented Navigation System (GAGAN) – India
- Wide Area Differential Global Positioning System (WADGPS) – South Korea (in development)
- System for Differential Corrections and Monitoring (SDCM) – Russia (in development)
- BeiDou Satellite Based Navigation Augmentation System (BDSBAS) – China (in development)

[1]FAA WAAS Quick Fact Sheet of 2/20/2017
[2]www.gps.gov/technical/ps/2008-WAAS-performance-standard.pdf Oct 31, 2008

- 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

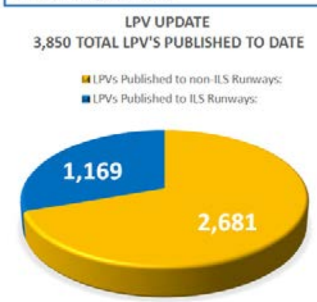
WAAS LPVs

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-IL Runways	Total
LPV Line of Minima	1,169	2,681	**3,850**
<250' Decision Altitude			*1,020*
Exactly 200' Decision Altitude			*975*
LP Line of Minima	3	641	**644**
LNAV Line of Minima	2,437	3,715	**6,152**
LNAV/VNAV Line of Minima	1.956	1,771	**3,727**
GPS Stand-Alone Procedures	4	70	**74**
GLS Approach	11		**11**

(Data as of August 28, 2017)



EGNOS LPVs

The number of LPVs in Europe is also growing. The table to the right shows LPV procedures in Europe as of June 22, 2017, as included in the EGNOS Bulletin Quarter 2. (Source: EGNOS Bulletin, Issue 23 Q2 2017)

Follow this link to the most recent EGNOS Bulletin Issue 23 Q2 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	90	141
Germany	22	36
Guernsey	1	2
Hungary	0	0
Ireland	1	1
Italy	9	19
Netherlands	2	3
Norway	16	24
Poland	5	9
Portugal	1	2
Romania	1	2
Slovak Republic	2	4
Spain	2	4
Sweden	1	1
Switzerland	7	9
United Kingdom	14	31
Total	**191**	**321**