INDUSTRY

WAAS/GPS:

Benefiting Early Adopters

STORY BY BY DAVE HIGDON

A minor milestone passed largely unnoticed back in December 2009 — the decade anniversary of when the first signals for a new precision navigation system began streaming down from space, sent from special satellites parked high overhead.

This first step in a fast march to establish the wide-area augmentation system supported a broad mission to increase the accuracy of the main global positioning system constellation.

A decade ago, WAAS still faced multiple challenges, first among them merely getting the infrastructure fully in place and functional. In parallel, WAAS also faced rigorous testing to affirm its functionality and reliability, no easy task amid seemingly never-ending funding pressures.

And then there was the issue of the flying public. For WAAS to mean anything, operators and aviators alike faced the costs of new equipment capable of using the new system in the real world — a world where approaches and procedures had to be developed and established to achieve the big payoff for users and regulators.

Today, the payoff exists and continues to expand. WAAS/GPS now supports more precision instrument approaches than the venerable instrument landing system, as the FAA recently reported.

New high-precision arrival and departure procedures help air carriers trim minutes from their en-route times, contributing to millions in fuel savings, smoother traffic flow and improved arrival rates in the poorest weather.

Today, according to FAA Administrator Randy Babbitt, more than 32,000 aircraft fly WAAS-equipped, -capable and -approved.

> "Manufacturers provide WAAS capability on GPS receivers ranging from handheld navigators to turbine-cockpit flight management systems — and pretty much everything in between.

And the number of WAAS-equipped aircraft and WAAS-supported procedures continue to grow daily, with aircraft OEMs offering upgrades to older aircraft and avionics manufacturers offering replacement, retrofit and new-installation products that embrace WAAS.

Quite a journey for a decade.

Getting Here from There

A decade ago, GPS already supported en-route and terminal navigation with accuracy high enough to support non-precision instrument approaches at greater accuracy and usually with lower minimums than any available ground-based guidance.

The accuracy promised from WAAS-enhanced GPS signals promised significant advances in accuracy, benefiting navigation, surveying and mapping, as well as something akin to the Holy Grail of operations within aviation circles, the big promise of super-accurate satellite navigation: satellite-guided precision instrument approaches with accuracy comparable to the gold standard of the ground-based approaches, the instrument landing system or ILS.

The first broadcast of WAAS signals in December 1999 opened the door to the FAA's intense testing while establishment of the ground network proceeded. Thanks to progress made, the FAA officially commissioned WAAS for aviation use in July 2003.

In 2004, the agency granted TSO approval to the first WAAS/GPS navigator capable of using the new precision signal, the Garmin GNS 480. With this door open, the impact of WAAS enhancement grew rapidly and continues unabated.

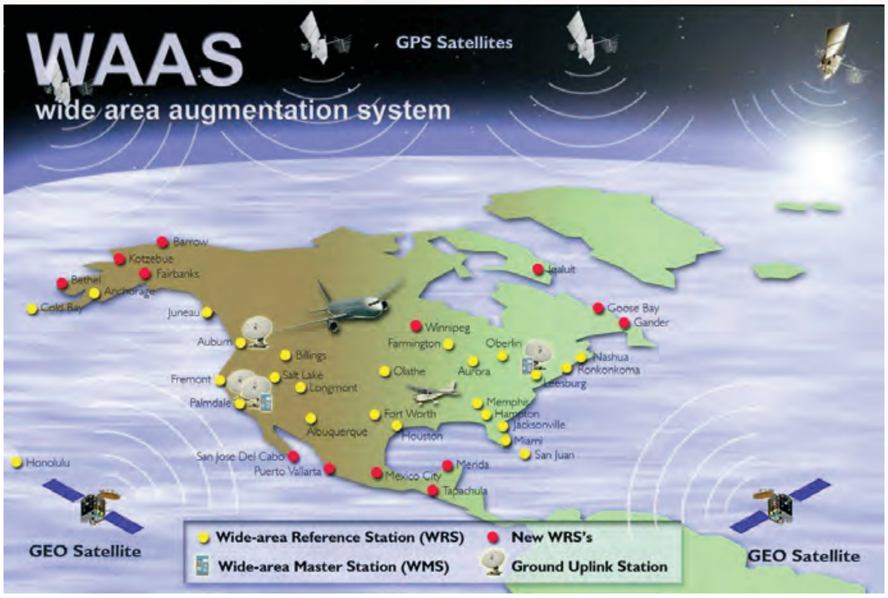
With the system capability now firmly in place for more than six years and the avionics growth since its commissioning, WAAS capability permeates through the selection of GPS navigators. Manufacturers provide WAAS capability on GPS receivers ranging from handheld navigators to turbine-cockpit flight management systems — and pretty much everything in between. WAAS even enhances aviation items, such as electronic flight bags with the navigation capability and geo-reference aircraft icon on the chart or plate.

Unfortunately, a, significant problem plagues the WAAS universe, one authorities hope to resolve later this year. But this issue, a satellite problem, helped renew discussions about the need for a backup system for GPS and WAAS.

Fortunately, this problem seems to have limited impact on the nearly 2,100 runway ends boasting the new instrument approaches WAAS has made possible. And the FAA promises several hundred more each year through the decade's end.

WAAS: The System

If you already are familiar with the basics of GPS, you're most of the way there. GPS, developed during the past 30 years by the Department of Defense, employs more than two dozen satellites in low-Earth orbit. Those satellites broadcast time-coded signals heard by GPS receivers; these receivers compare the data from three or more satellites and use the coded data to calculate their position on or over Earth.



While the precision of the data broadcast and receivers' capability is high, small technical issues can compound to reduce the accuracy of the receiver's calculations.

Among those issues are satellite movement or drift, tiny clock errors, and signal-travel variations caused by atmospheric conditions. When compounded, these typically small input flaws generate

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position errors in the receivers' calculations; receivers' accuracy abilities are only as good as the data they use to make the calculations.

As a result, nominal GPS accuracy is between 50 and 100 feet laterally and vertically.

The FAA and its contractors created the WAAS system to correct such errors and provide corrected information to receivers.

The WAAS architecture involves more than 25 geographically diverse ground stations, each one precisely surveyed with its known position used to compare its own position to calculation of the regular GPS satellite signals.

In the simplest terms, WAAS ground stations work like normal GPS receivers with a crib sheet — they actually know where they are and can compare this knowledge to the calculation that results from the satellite data.

When these ground stations detect inaccuracies, they send a correction for their region to a set of master stations, which process the information and send it back to a pair of geostationary WAAS satellites parked above North America.

Those satellites, in turn, broadcast corrected signals on a separate frequency, corrections tailored to each ground station's service area.

The WAAS channel in the GPS navigator receives the correction signal, which results in demonstrated accuracy of about 9 feet, laterally and vertically. The demonstrated accuracy far exceeds the goals of 50 feet laterally and 66 feet vertically; furthermore, the system reportedly never has shown errors in excess of about 40 feet.

This vertical accuracy capability, in particular, underpins a family of new instrument approach procedures known as lateral precision with vertical guidance, or LPV, as well as other benefits, such as required navigation performance arrival, departure and newer RNAV approach procedures.

Starting after these years of culminated efforts, with WAAS commissioning in 2003, hundreds of runway ends either have or can get a precision-approach procedure capable of guiding airplanes down to as low as 300 feet above the ground at most airports, and as low as 200 feet at airports with the proper lighting and runway aids. This is as good as the ILS, but without the $1.5 million to $2 million equipment, site-preparation, installation and testing costs.

By contrast, the FAA pegs the cost of a new LPV approach at under $50,000 — less when the agency tackles creating multiple approaches at one airport at the same time.

The results of this new capability are striking. As of mid-April, more than 2,000 new LPV approaches were operational, with more than 4,600 of the others and more to come.

These new approaches — LNAV, LNAV/VNAV and LPV — benefit nearly 500 non-Part 139 airports and more than 50 Part 139 airports. Clearly, the system is delivering on its promise of enhancing IMC access to smaller airports.

And this number doesn't cover those RNP procedures, which helped expand arrival and departures at many airports.

New Access in New Ways

With WAAS/GPS capable of supporting a number of new ways for aircraft to get around when the weather goes down, the FAA has focused considerable resources on expanding the availability of these procedures, which are only possible with WAAS receivers — and, in some cases, special approval for aircraft and pilot training to use them.

Here's a snapshot of the benefits from WAAS and what they offer pilots:

• RNP: Required navigation performance uses WAAS/GPS — alone or with other inputs, such as inertial reference and inertial navigation inputs — to provide precise defined navigation as the primary source of guidance. RNP standards define small route corridors that can be used in transitions, arrivals, departures and approaches where geographic features or traffic densities otherwise make the usual arrival types impractical or excessively risky. Curved approaches in mountainous areas or within the arrival routes of a different airport in busy airspace are among the signature advantages of meeting RNP standards.

RNP capabilities are defined by the degree of accuracy they provide, with RNP 1.0 at one mile, all the way down to RNP 0.3 — yes, three-tenths of a mile for approaches and certain transitions. To obtain FAA use of RNP-based procedures and benefits, the aircraft's navigation system must monitor its own accuracy and provide a means to alert the flight crew should accuracy become suspect. Both aircraft and crew also must obtain Special Aircraft and Aircrew Authorization Required — or SAAR — approval to fly RNP procedures.

• LPV: Lateral precision with vertical guidance is the highest level of WAAS approach not requiring special aircrew training or certification. LPV provides the greatest precision outside the RNP environment — greater than the LNAV or LNAV/VNAV approaches. Essentially, the WAAS/GPS provides for precise lateral and vertical guidance with the WAAS navigator showing the aircraft's position in reference to the published approach stored in its memory.

With the WAAS/GPS tracking and

comparing the aircraft to the defined centerline and glide path, the pilot sees indications akin to the VHF indicator on an ILS approach: the course deviation indicator shows offset from the runway centerline and a glide-path position indicator shows the plane's position relative to the pre-programmed-but-imaginary glideslope leading to a touchdown point beyond the runway threshold.

Nearly 2,100 LPV approaches existed as of April. More than half of them were at airports lacking an ILS; many others went to ILS-served airports, but for runway ends not so equipped.

LPV approaches also are the most common type of approach now, exceeding even CAT I ILS approaches and the approach most general aviation pilots are apt to employ with their new WAAS navigators.

• LNAV: This sort of approach also can provide curved guidance, but the vertical guidance is dependent on actual barometrically corrected local altimeter settings for flying the correct altitude at designated points on the approach. The FAA has commissioned about 4,600 LNAV approaches as of early April.

• LNAV/VNAV: An LNAV approach with the vertical descent path defined by a GPS-generated glide path displays a continuous target altitude for the path and leads to a DH comparable to the non-precision GPS approac. A certified altimeter input for the GPS must be part of the package. About 2,000 LNAV/VNAV approaches existed as of early April.

• GPS approach: This form of non-precision approach was first deployed in the early 1990s, when the first approach-capable navigators began appearing in aircraft cockpits. Most of these approaches were drawn as overlays over existing non-precision approaches — NDB, DME arc and VOR approaches. The FAA created others as standalones, using arrival procedures more akin to an ILS or LOC approach,

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but solely dependent on local altimeter settings and an accurate altimeter.

GPS approaches generally ended at a lower DH than any existing NPA. As more WAAS approaches have come into existence, the number of GPS approaches supported has declined. The FAA expects to continue to shrink the number of GPS approaches from the latest number of about 540 in early April.

WAAS Today: A Slightly Wounded System

On April 3, Intelsat, the FAA contractor controlling the WAAS satellites, lost control of the Pacific WAAS satellite and the bird began drifting out of orbit and out of use. That's one of two WAAS birds the system was designed to use for maximum service and coverage.

But there's no need to panic. According to the FAA and the Department of Transportation, a fully reliable WAAS/GPS remains available, working and accurate over about 95 percent of the North American coverage area with northwest Alaska the lone exception.

The agencies also cautioned three to five periods of unusable WAAS signals could occur during the year as the remaining satellite periodically shifts between ground links. But these periods are detectable and should be short in duration — about five minutes — according to the agency.

The FAA was working a fix for this problem, focusing primarily on accelerating testing and activation of a replacement satellite already in orbit. Another WAAS bird is due for launch later this year, but getting it into service will take about 18 months.

The FAA expects to restore full WAAS coverage around the end of 2010. In the meantime, the system is operating under a single-point failure mode, with only the one WAAS satellite supporting the service.

Thus, a renewed debate about the wisdom of shutting down Loran C stirred — actually, a debate about the need for an independent alternative system capable of picking up the jobs of satellites should they become unusable for any reason.

WAAS Tomorrow: More Utility for NextGen, ADS-B

While the wonders of LPV approaches and RNP procedures come into play today, in the here-and-now world of aviators flying appropriately equipped aircraft, another larger role looms for WAAS in NextGen.

With the FAA moving toward a system that uses aircraft-GPS-generated position reporting through the automatic dependent surveillance–broadcast, the accuracy of WAAS/GPS makes possible the reinvention of traffic monitoring and management, which both the agency and users are seeking.

WAAS-level accuracy can combine with ground hardware at airports to provide multiple simultaneous instrument approaches in the worst weather, with controllers confident of the position information before them, enhancing separation and traffic flow.

WAAS and ADS-B can help separate ground traffic and taxiing aircraft. And, as radar systems leave service, Air Traffic Control can operate using ADS-B position relaying with WAAS accuracy, allowing tighter spacing of aircraft and more direct operations — all based on the knowledge these position reports are the most precise ever made available for air-traffic management. ❑