



SatNav News

Garmin Offers WAAS LPV Receivers

by Tom Driehorst, GPS TAC/FAA ATO-W



New WAAS LPV Receiver - Garmin GNS 480

LPV-capable Wide Area Augmentation System (WAAS) avionics are hitting the marketplace. Garmin International's GNS 480 now meets the strictest level of certification for WAAS navigation. Previously, Instrument Landing System (ILS) availability was needed for a precision approach in low-visibility conditions. The GNS 480 will utilize satellite-

based nav aids for precise lateral and vertical approach guidance – similar to ILS operations – without the need for ground-based nav aids of any kind, since avionics certified to Gamma-3 requirements meet the FAA's standards for LPV guidance.

At the heart of the GNS 480 is a 15-channel WAAS receiver that updates the aircraft's position at a rate of five times per second. The GNS 480 provides oceanic-approved IFR GPS/NAV/COM functionality and ILS/VOR capabilities—but does so on a 3.8-inch (diagonal), 256-color moving-map display.

According to the Garmin representatives at the AOPA Expo, LPV upgrade modifications to the existing Garmin GNS 530/430 series avionics will be available in the summer of 2005 for approximately \$1,500. Current 530/430 users will need to send their unit to a factory facility to receive the modification.

WAAS - A Pilot's View

by Larry O. Oliver, GPS TAC/FAA ATO-W



I've spent many years using just Very High Frequency (VHF) Omnidirectional Range Receiver (VOR) for navigation. Eventually, I upgraded to Distance Measuring Equipment (DME), and found that my workload decreased and my navigational confidence went up immensely. Several years ago I started using the Global Positioning System (GPS), and I was amazed at the capabilities it presented. Suddenly, the old areas of navigational uncertainty were gone, and I could alter my destination en route with confidence in my time and distance to the new airfield. Now, I am faced with the Wide Area Augmentation System (WAAS). Frankly, I'm pretty happy—no, make that thrilled—with GPS, so what will WAAS get me?

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The **SATNAV News** is produced by the Navigation Services (ATO-W) branch of the Federal Aviation Administration (FAA). This newsletter provides information on the Wide Area Augmentation System (WAAS) and the Local Area Augmentation System (LAAS), and initiatives associated with the implementation of satellite navigation into the National Airspace System (NAS).

There are some minor discrepancies with basic GPS. First, the altitude function doesn't match with my altimeter. Second, doing Receiver Autonomous Integrity Monitoring (RAIM) predictions is a minor nuisance. Third, GPS approaches seem to have high minimums. Fourth, I can't file an airport Instrument Flight Rules (IFR) with only a GPS approach as an alternate. If WAAS could fix some of these, I'd be happy. I already know that GPS improves my navigational accuracy, allows more direct routing and improves safety by both allowing me to spend more time with my head out of the cockpit and by improving my situational awareness. So what am I really going to gain by adding WAAS?

The fact is that WAAS fixes all of these, and it does even more. WAAS improves both horizontal and vertical accuracy of GPS to about two meters. Second, WAAS improves upon the integrity of GPS, and obviates the need for RAIM. Third, WAAS has introduced a new approach called LPV, which has minimums as low as 250 feet and provides an Instrument Landing System (ILS)-like glide slope. Fourth, I can now use an airport as an alternate even if the only approach is GPS. I can't use the LPV minima-line, but I can use the GPS minimums. In addition to LPV approaches, I can use WAAS to fly lateral navigation/vertical navigation (LNAV/VNAV) approaches to the VNAV minimums. This provides me with about 800 new approaches in the United States, and the number is growing rapidly. I will probably find an additional 100+ approaches in the next year.

Probably, the biggest benefit of WAAS will be what it allows me to do in the near future. The FAA is redesigning much of the airspace system, and it is also moving toward a system based upon Required Navigational Performance (RNP). This means that my aircraft will have to meet specific navigational accuracy capabilities for me to be allowed to operate in different classes of airspace or fly certain arrivals, departures and approaches. While aircraft can meet the RNP requirements through a variety of means, WAAS offers the least expensive means—especially when compared to the cost of a flight management computer and integrated dual DMEs to update it.

I've been around long enough to be able to recognize trends—especially a trend that has had this kind of money spent on it. The government has spent money putting up dozens of navigation satellites, and continues to develop and launch new

navigation satellites. It isn't putting up new VORs, and it certainly isn't putting up more Non-Directional Beacon (NDBs). In fact, they are talking about decommissioning many of the older nav aids, so the priority will be on satellite-based navigation aids. WAAS is in service and the FAA has committed to publishing 100 new LPV approaches this year (FY05) and 150 new approaches in FY06. So my choice is whether to become an early user, or wait until I'm facing extinction by not being able to fly to my intended destination because I lack the equipment. Cost isn't really an issue, because most GPS receivers can be upgraded for a reasonable charge.

So what does WAAS mean to me as a pilot? It means more safety, fewer restrictions in flight planning and destination selection and the proven capability of being able to navigate my aircraft with an accuracy of a couple of meters for the entire duration of my flight. For a guy who used to navigate by reading the town name off the local water tower, I think WAAS is wonderful!

Additional WAAS Reference Stations in Alaska

by Wally Peterson, GPS TAC/FAA ATO-W

The Wide Area Augmentation System (WAAS) enhancement program completed a milestone at the end of September with the physical installation of four new WAAS Reference Stations (WRS) in Alaska. This is the culmination of a lengthy process starting from site selection, through site surveys and



WAAS Reference Station in Barrow, Alaska

finally, the physical installation and checkout of the equipment. The process of installation was a team effort utilizing resources from the Federal Aviation Administration (FAA) Alaska Region, FAA National Airspace System Implementation Center (ANI), FAA Technical Center, FAA WAAS Product Team, and Raytheon Company.

The WRSs installed in Alaska are comprised of all new equipment, designed by Raytheon Company, to support the planned improvements to the WAAS. These installations will be operational in the WAAS in December 2005 and are located at Barrow, Bethel, Fairbanks, and Kotzebue. Prior to the operational date, the WRSs will be utilized to evaluate the safety implications of the installations on the WAAS signal-in-space and to support software development and integration. Additionally, changes to the corrections and verifications subsystems and the operations and maintenance subsystems will be completed in order for the WAAS to utilize the new WRSs. Once those efforts are completed, the change process allowing the integration of the sites into the WAAS is complete and the FAA technicians are trained to operate and maintain the sites, the sites will be commissioned and cut into the WAAS.

Mexico WAAS Project

by Joaquin Diaz Garcia, SENEAM

Translation to English by Jorge Boubion, WAAS Operations Lead, Pacific Desert Systems Management Office

The increasing demand of air traffic and how to satisfy this demand has been one of the principle goals of the International Civil Aviation Organization (ICAO). The ICAO Transition and Implementation Plan for CNS/ATM system integration supports a global, safe and standardized air space. The ICAO plan utilizes high-precision equipment and new air traffic procedures to increase this air space capacity.

Mexico's Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM) is an enthusiastic participant in this transition to a global air space. It is important to emphasize that GPS data collected by the Instituto de Geofísica (www.igeofcu.unam.mx) was used to model ionospheric behavior as it relates to WAAS performance requirements.

ICAO's Global Navigation Satellite System (GNSS), enhanced with an open-architecture digital telecommunications network, satisfies the availability, reliability, precision and integrity requirements for aviation.

The GNSS utilizes the augmented Global Positioning System (GPS) to meet the requirements for aviation. For more than a decade, the research and development of the GNSS has culminated with the certification and acceptance in the United States of the Wide Area Augmentation System (WAAS) on July 10, 2003.

Research and development in the early 1990s created the National Satellite Test Bed (NSTB) and it was considered to be a prototype of the WAAS. In 1999, Mexico's SENEAM, under a technical cooperation agreement with the Federal Aviation Administration (FAA), decided to install three NSTB reference stations in Mexico. In that same year, SENEAM and FAA technical personnel completed the installation and these reference stations became operational at Mazatlán, Mexico City and Mérida airports.

On March 21, 2001 (Spring Equinox), near-precision flight tests were conducted at Mérida Airport with intent to evaluate the feasibility of approaches using GPS in Mexico. The March 21 date was chosen because it is at this time when solar activity is at its greatest and greatly effects the propagation of electro-magnetic signals through the ionosphere. Modeling ionospheric behavior during solar storms was fundamental to the development of the WAAS. Since 2001, NSTB reference stations have been critical and important in collecting GPS data. Data from these test reference stations is used to model ionospheric behavior in the airspace. No GPS data was collected between January 2000 through March 2001.

SENEAM searched science and educational institutions in Mexico for possible sources of empirical GPS data that could benefit air navigation. The Instituto de Geofísica, Universidad Nacional Autónoma de México, provided this data with promising results.

The Instituto de Geofísica has over one dozen GPS stations. Data received from these stations is used for studies within

the different regions of Mexico in geophysics and tectonics to define reference marks of earth deformations and movements.

The contribution of the Instituto de Geofísica has been important and is currently being analyzed by the Jet Propulsion Lab of National Aeronautics & Space Administration (NASA).

In accordance with the agreement between SENEAM and FAA, three WAAS reference stations (WRS) are scheduled to be installed in 2005. The WRSs will be located at México City, Mérida and Puerto Vallarta airports and should be ready for operational use in 2006. In 2006, two additional WRSs are scheduled to be installed and will be located at Tapachula and La Paz airports. They should be operational in 2007. The WAAS service volume coverage is expected to extend with the installation of these WRSs and is predicted to benefit the GNSS for users and service providers.

Proyecto WAAS En Mexico

by Joaquin Diaz Garcia, SENEAM

La creciente demanda del tráfico aéreo y como satisfacerla ha sido uno de los principales retos de la Organización de Aviación Civil Internacional. Su Plan de Transición e implementación para la migración a Sistemas CNS/ATM pretende un espacio aéreo global seguro y uniforme utilizando equipos con mayor precisión y nuevos procedimientos mediante los cuales se incremente la capacidad de dicho espacio.

México, a través de Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM), ha sido un entusiasta participante en esta transición. Es interesante resaltar la utilización de los datos GPS del Instituto de Geofísica (www.igeofcu.unam.mx) dada la convergencia de su área de interés, el comportamiento ionosférico como precursor sísmico, con el requerimiento del WAAS de modelar dicho comportamiento ionosférico.

Es por todos conocido que la Organización de Aviación Civil Internacional (OACI), planea usar un Sistema Mundial de Navegación Satelital (GNSS), integrado con una red de telecomunicaciones basada en tecnología digital y arquitectura abierta que satisfaga los requerimientos de la aviación en cuanto a disponibilidad, continuidad, precisión e integridad.

El Sistema de Navegación y Vigilancia referido prevé utilizar el Sistema Global de Posicionamiento (GPS) mejorado para cumplir con los requerimientos que exige la aviación. La investigación y desarrollo de este Sistema por mas de una década ha culminado con la certificación y aceptación en Estado Unidos, del Sistema Mejorado de Área Amplia (WAAS) realizada a principios de este año.

A principios de los 90's y con propósitos de investigación y desarrollo, fue creada la plataforma de Navegación Satelital (NSTB), o prototipo del Sistema WAAS. En 1999 México, a través de Servicios a la Navegación en el Espacio Aéreo Mexicano, (SENEAM) bajo un acuerdo de cooperación técnica con FAA, dispusieron instalar 3 estaciones de referencia en México. En ese mismo año se capacitó personal técnico de SENEAM, el cual conjuntamente con personal de FAA, llevó a cabo la instalación y puesta en operación de las Estaciones de Referencia en los Aeropuertos de Mazatlán, México y Mérida.

En Marzo 21 DEL 2001 (Equinoccio de Primavera), se realizaron en el Aeropuerto de Mérida pruebas en vuelo con aproximaciones de precisión WAAS/NSTB. Los vuelos fueron programados en esa fecha para tener las condiciones de mayor afectación a la propagación de las señales electromagnéticas y así evaluar su factibilidad de operación en México. Los resultados confirmaron la factibilidad de utilizar el Sistema WAAS en el Espacio Aéreo Mexicano, con la Instalación de las correspondientes estaciones de referencia. Es fundamental para la operación del Sistema WAAS, modelar el comportamiento Ionosférico, aun en condiciones de comportamiento crítico para la propagación de Ondas Electromagnéticas, como sería durante períodos de tormentas solares. Para lo anterior, la operación de las Estaciones de Referencia de la plataforma de prueba ha sido importante contándose con datos recibidos de GPS permitiendo conocer el comportamiento de la Ionosfera, en el Espacio Aéreo Mexicano desde 2001, sin embargo un periodo crítico e importante para el análisis, y del cual no se contaban datos GPS es de Enero 2000 a Marzo del 2001.

Por lo anterior SENEAM, se abocó a indagar en Empresas e Instituciones Educativas las posibles fuentes de datos GPS, que pudieran compartir en beneficio de la Navegación Aérea. Con ese propósito se contacto al Instituto de Geofísica,

perteneciente a la Universidad Nacional Autónoma de México, con resultados positivos.

El Instituto de Geofísica posee más de una docena de Estaciones GPS que utiliza como herramienta de algunas de sus áreas de Investigación y mediante las cuales, con la información obtenida realiza estudios de Geodinámica y Tectónica para definir el marco de referencia de deformaciones y movimientos corticales que experimentan las diferentes regiones de México, causadas por su entorno Geológico como son límites convergentes de placas, Vulcanismo, Geofísica Marina, etc.

La contribución del Instituto de Geofísica, ha sido importante y actualmente sus datos compartidos se encuentran analizándose en el Laboratorio JPL de la NASA.

Conforme a lo acordado entre FAA y SENEAM, se pretende instalar tres estaciones de referencia durante 2005 (México, Mérida y Puerto Vallarta), para su operación en 2006, y dos estaciones (Tapachula y La Paz), en 2006 para su operación en 2007. Con la Instalación de estas Estaciones se pretende extender la cobertura actual del Sistema WAAS, con los consecuentes beneficios que el Sistema Global de Navegación Satelital prevé para sus usuarios y proveedores del servicio.

FAA LAAS and European GBAS Working Group Meeting

by **Dieter Guenter**, GPS TAC/FAA ATO-W



In December, the Federal Aviation Administration (FAA) Local Area Augmentation System (LAAS) program team hosted the most recent meeting of the Ground Based

Augmentation System (GBAS) Working Group. The European GBAS working group was established several years ago as forum for the development of GBAS technology, for the evaluation of GBAS benefits, and for the development of a GBAS implementation strategy for Europe. The last meeting

was hosted by EUROCONTROL at the Eurocontrol Technical Unit in Bretigny, France in April 2004.

As a result of the FAA decision in 2004 to move LAAS to a research and development program, European service providers were prompted to re-evaluate their GBAS activities. Many of the service providers had aligned their national GBAS programs with the FAA LAAS program schedule and were planning on LAAS being available in 2006. Representatives from the FAA's LAAS team agreed to provide information on current LAAS plans and activities at the December GBAS meeting to support Europe in the re-evaluation of their plans.

At the meeting, the FAA team reported substantial progress in several areas of LAAS development. Most significant progress was made in two of the most demanding technical areas of the program - ionospheric threat definition and monitoring, and LAAS ground error overbounding and monitoring analysis. Both these technical risk areas are managed by implementing proper mitigation options. Currently, the ratings for both risks have been reduced from high to medium.

In the area of ionospheric threat definition, a deficiency in integrity monitoring was identified due to recent developments in the ionospheric behavior studies of other programs. A LAAS Ionosphere Working Group was formed with participation from research scientists from FAA, Honeywell, and Stanford University to address this issue. The working group successfully modeled the worst-case ionospheric threat to LAAS and gained consensus between the stakeholders in the government and in the industry. The working group also proposed different ways of monitoring for the ionospheric threat without any changes to the existing safety requirements and standards. One such method of ionospheric threat monitoring implementation is already mature, the others are under investigation.

The other risk area where major progress has been made is LAAS ground error overbounding and monitoring analysis. Ground errors need to be defined and bounded for the system to achieve required safety objectives such as continuity and integrity. Previously, lack of data and analysis of confi-

dence marred establishment and monitoring of this most critical safety parameter in the system. Now, through the use of large amounts of data collected at the FAA Tech-



nical Center using the sophisticated LAAS Test Prototype and combined with brain power from the FAA, Ohio University, Stanford University, and Honeywell, a consensus has been reached on a road map to solve this problem. A methodology has been established to overbound and monitor the ground errors with sufficient confidence. Other issues related to the problem, such as the false alarm rates, are currently under investigation. The progress made by the FAA team and Honeywell was considered an important improvement in the development of GBAS CAT I technology and encouraging information for nations with existing prototypes and funded GBAS programs.

Discussions and presentations from the individual service providers showed the effect that FAA program uncertainties have had on the national strategy of many service providers. Most of these service providers still consider GBAS to be the precision approach technology of the future. They continue to support GBAS activities either through CAT II/III standards development or through plans with their national regulatory agencies and European airlines for early operational approval. Especially interesting were the plans of Aeropuertos Espanoles y Navegación Aérea (AENA) in Spain with national flight inspection aircraft and Air France at Malaga airport and their desire to implement GBAS CAT I as soon as possible. In Germany, Deutsche Flugsicherung GmbH (DFS) is working with Lufthansa at Frankfurt and Bremen airports to achieve early operational approval for GBAS CAT I systems and is also focusing on the development of a concept of operations. Skyguide of Switzerland has already changed their original GBAS implementation plan due to FAA program changes and has instead acquired a high cost "End Fire" Instrument Landing System (ILS) system at Zurich airport. Brazil plans were presented by the FAA and are similar to other service provider plans with emphasis on an early operational approval of GBAS technology.

EUROCONTROL outlined some related European GBAS activities and presented the Eurocontrol Landing and Take

Off work program (LATO). The outcome of the EUROCONTROL xLS business case showed that an overall transition from ILS to either Microwave Landing System (MLS) or GNSS Landing System (GLS) was not cost efficient for Europe, however, local requirements could drive the need for either MLS or GLS. Consequently EUROCONTROL support will continue for the GBAS development for the European states that are willing to implement GBAS operationally and technically. Germany, Spain, Switzerland, France and Italy remain engaged in GBAS activities at different levels, while the UK is focusing on MLS implementation.

This meeting also included participation of users/potential future customers (Continental Airlines) and aircraft manufacturers (Boeing and Airbus). Their involvement reinforced user support for GBAS, which remains very strong and visible in the involvement of different airlines in the US and Europe. Boeing and Airbus presented a strong common GLS position, outlining the need for quick GBAS implementation due to the ongoing certification activities in the US and Europe and a window of opportunity regarding avionics finalization for the Boeing 7E7 and Airbus A380, respectively. They outlined the urgent need for operational GLS experience, starting with CAT I systems, and reiterated the need for clear policy, planning, and realistic deadlines.

The technical, operational and programmatic discussions proved to be a valuable information exchange between participating national and international organizations and are considered an important vehicle for coordinating activities outside of the ICAO or RTCA-JAA meetings. Overall, it was agreed that the GBAS working group and the FAA LAAS team should continue their close coordination. In addition, more detailed areas of cooperation were outlined, which include ionosphere, GBAS safety case, GBAS CAT III concept of operations and GBAS early operational activities. Concurrently, national representatives will continue assessing the impact of FAA program decisions on their national GBAS plans. The next GBAS meeting is planned for June 2005.



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