



SatNav News

Airports Get New WAAS Approaches

by **Mary Ann Davis, GPS TAC/FAA ATO-W**



Every 56 days, the FAA increases the number of the Wide Area Augmentation System (WAAS) approaches available at airports across the U.S. Since the last edition of the *SatNav News*, 81 new WAAS approaches have been published. To date, the FAA has published 138 LPV approaches.

A WAAS approach, also known as an LPV (Localizer Performance with Vertical guidance) can guide aircraft almost as low as an Instrument Landing System (ILS). LPVs can achieve minimums as low as 250 feet above touchdown and, like an ILS, LPVs provide pilots a line-in-space, or glide slope, that can be followed down to just above the runway. These types of vertically-guided approaches are proven to be much safer than approaches that only provide lateral guidance. Unlike ILS, WAAS requires no navigation equipment be installed at the airport. The benefits of LPVs include safer approaches, better airport access in poor weather, and in many cases, the elimination of awkward and tedious circling maneuvers that in the past introduced difficulty to the pilot and additional engine noise above nearby neighborhoods.

If you are an airport owner, you may be wondering how and when you can get an LPV for your airport. Here is some information that may be helpful. The FAA has an Office of Management and Budget goal to produce 300 LPV procedures for non-ILS runway ends per year starting in fiscal year 2006. There are thousands of non-ILS public runway ends, so the FAA is working closely with the aviation community to help prioritize development to best serve the aviation community. (There are some runway ends receiving LPVs that currently have an ILS, but these will not be counted toward the annual goal of 300.) Another factor that the FAA is considering when prioritizing LPV development is the number of operations at each airport.

For a list of current LPV approaches, statistics on LPV development, and a list of future procedure publication dates, please visit <http://gps.faa.gov> and select the GPS/WAAS Approaches button from the front page. For a tentative schedule of future LPV development or information on how to request an LPV for your airport, please visit <http://avnweb.jcabi.gov/schedule/production>. The next procedure publication date is September 1, 2005.

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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).

WAAS GEO Contract Award

by Mary Ann Davis, GPS TAC/FAA ATO-W

On March 17th, 2005, the FAA signed a contract modification with Lockheed Martin fully definitizing the costs and terms of the Geostationary Communication and Control Segment (GCCS) service. The signing of the modification completes the terms and agreements initially set forth in the letter contract awarded to Lockheed Martin in 2003. Since the lead-time to procure satellite services is significant, the FAA signed a letter contract with Lockheed Martin in 2003 to get development underway. The definitized contract solidifies cost, schedule, and service details which were unknown at the time of the letter contract signing. With the definitization of the GCCS contract, the next phase of geostationary satellite (GEO) service for the WAAS is secured. This milestone follows significant technical, contractual, and logistical work by the FAA, Lockheed Martin, and supporting organizations. The contract provides ten years of GEO service for the WAAS to start in 2006 and extend through 2016.

New Satellites Being Prepared for WAAS Service

by Ed Sigler, GPS TAC/FAA ATO-W

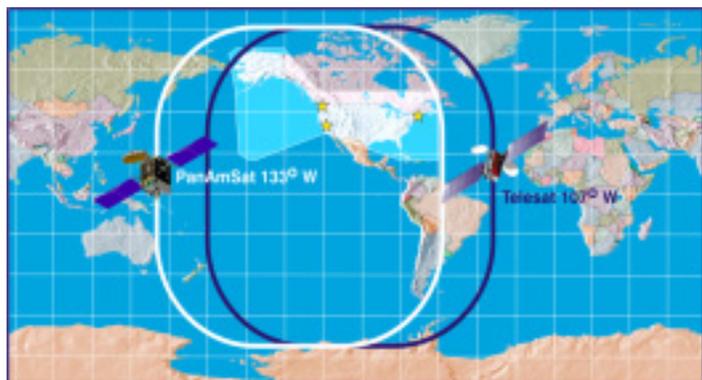
New WAAS navigation payloads to be hosted on geostationary satellites (GEO) are being prepared for service. The leases for the current WAAS GEO service, provided by Lockheed Martin using Inmarsat 3 satellites, expire in late 2006. The goal of the FAA is to replace the current leased GEO services with the new GEO services, providing better broadcast coverage over the U.S. To secure this new service, the FAA signed

a Geostationary Communication and Control Segment (GCCS) contract with Lockheed Martin in March 2003. As a part of this contract, Lockheed Martin and the FAA have been involved in preparations to host WAAS navigation payloads on two new GEO satellites - Galaxy XV to be launched for PanAmSat, and ANIK F1R to be launched for Telesat.

In December 2004, a WAAS navigation payload was fully integrated onto the Telesat ANIK F1R. When Telesat is in orbit and operational, the WAAS navigation payload will relay the WAAS signal from uplink stations on the ground to users within the satellite footprint (denoted by the yellow ring in the graphic). The Telesat GEO is scheduled for launch later this summer and is expected to become operational within the WAAS in late 2006. The payload for the PanAmSat Galaxy XV GEO is currently undergoing integration and testing and is expected to be launched later in 2005.



Representatives from the FAA, Lockheed Martin, and PanAmSat at the Ribbon-Cutting Ceremony for the New GCCS GUS in Napa, California



Broadcast Footprints of Future WAAS GEOs

In addition to new GEOs, new ground uplink stations (GUSs) are being installed to transmit the WAAS signal to the new GEOs. On Tuesday, February 22nd, a ribbon cutting ceremony was held in Napa, California to celebrate the completion of the first GUS site constructed under the Lockheed Martin GCCS contract. This GUS will transmit the WAAS message and integrity data to the PanAmSat satellite scheduled for launch this summer.



GUS Facility in Napa, California

The 2nd GUS station in the PanAmSat pair, located at Littleton, Colorado, was completed this past spring. The GUS pair for the Telesat GEO, which will be located at Brewster, Washington and Woodbine, Maryland are under construction with completion expected in early fall.

Installation of New WAAS International Reference Stations Underway

by Wally Peterson, GPS TAC/FAA ATO-W

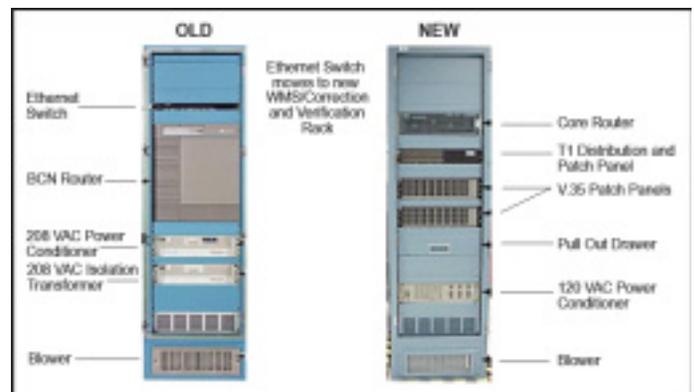
The FAA continues its progress toward the goal to expand LPV capability for WAAS with the addition of five new Wide-area Reference Stations (WRS) this fiscal year. WRS installations are being conducted in Mexico at Mexico City, Merida and Puerto Vallarta; and in Canada at Gander, and Goose Bay from June through September. This work is the culmination of efforts that have been ongoing for two years and reflect significant interaction and cooperative detailed planning between the U.S., Canadian, and Mexican governments and other interested parties. These WRS locations will enhance WAAS coverage for the U.S. and also improve the utility of WAAS for the other countries in concert with the FAA Administrator's international goals.

WAAS Communications Network Receives Upgrades

by Frank Woelfle, GPS TAC/FAA ATO-W

The Wide Area Augmentation System (WAAS) Telecommunications Subsystem (TCS) is being upgraded to provide the foundation for future WAAS enhancements. As a part of the upgrade, two new racks of WAAS equipment have been installed at each of the WAAS backbone sites. These sites are located in Air Route Traffic Control Centers (ARTCC) in Chicago, Atlanta, Los Angeles, and Washington, D.C. Additionally, two new racks of WAAS equipment were installed at the Seattle ARTCC to establish a gateway between the seven Alaskan WRS satellite circuits and the existing continental U.S. (CONUS) terrestrial backbone circuits.

This new equipment increases WAAS network capability. This additional capability is needed to support the 13 new WAAS Wide-area Reference Stations (WRS) being installed in Alaska, Canada, and Mexico; and the new WAAS Wide-



area Master Station (WMS) being installed in Atlanta. The 13 new WRS will be added to the existing 25 operational WRS's during the 2006-2007 time frame. Additionally, the TCS upgrade will handle the four new ground uplink station (GUS) sites required to support two new Geostationary Communication and Control Segment (GCCS) geostationary satellites that will go on line in 2006 -2007 to provide the WAAS network with greater availability, reliability and performance.

In addition to increasing network capability, this new TCS equipment:

- Lowers equipment removal/replacement time
- Lessens procedures for fault isolation
- Removes the non-procurable power supply from WAAS parts inventory
- Provides technicians with a co-located patch panel for trouble shooting.

The WAAS TCS is a physically diverse and secure network used to transfer data between geographically-dispersed components of the WAAS. Although most of the network is terrestrial, satellite services are used to reach locations with little or no terrestrial communication infrastructure.

14th Meeting of the SBAS Interoperability Working Group

by Deane Bunce, FAA ATO-W GPS Satellite-Based Augmentation Group

The 14th meeting of the Satellite-Based Augmentation System (SBAS) Technical Interoperability Working Group (IWG) was held on March 29-31, 2005 at the Torrejon European Geostationary Navigation Overlay Service (EGNOS) Master Control Center (MCC) in Madrid, Spain. The meeting was hosted by the Spanish Airports and Air Navigation Office. The IWG was established in 1997 by the project teams involved in the development and implementation of SBASs. The meeting forum has allowed SBAS project teams to work together to resolve common technical issues, with the goal of making SBAS a seamless global service. Participants for this meeting included representatives from the Wide Area Augmentation System (WAAS), EGNOS, Multi-function Transport Satellite (MTSAT) Satellite-Based Augmentation System (MSAS) and Canadian WAAS (CWAAS) project teams.

As part of each IWG meeting, the status of each SBAS project is provided. Of interest at this latest meeting was that both

the EGNOS and MSAS projects now have dates planned for the operational approval of their systems. EGNOS plans to commission the use of EGNOS for safety-of-life applications in late 2006. For MSAS, it will begin with the broadcast of information in a test format using their recently launched MTSAT satellite. The test format (Message Type 0) allows MSAS to broadcast both corrections and integrity information that can only be received and used by test equipment. The Japanese Civil Aviation Bureau currently plans to commission MSAS sometime in mid-2006. In addition, the Canadians are working to gain operational approval for use of WAAS in Canada this year.

A main topic of discussion for this meeting was the progress made in the area of SBAS receiver development. At present, RTCA is working on publishing the next update to the Minimum Operational Performance Standards (MOPS) for GPS/WAAS airborne equipment. For this meeting, there were a number of open issues discussed that focused on some of the differences in the WAAS and EGNOS implementations and how these differences relate to specific MOPS requirements. Resolution of these issues is on-going. The direction and schedule of Global Navigation Satellite System (GNSS) modernization activities also has an impact on the development of SBAS-related standards. Incorporation of L5 and Galileo and the development of associated standards were discussed. It was agreed that incorporation of a second civil frequency was a goal for all SBASs and that it was also required to support SBAS vertically-guided approaches in the equatorial regions of the globe. A goal of the IWG has been to develop a coordinated SBAS position on standards related issues that could then be taken to the International Civil Aviation Organization's (ICAO) Navigation Systems Panel (NSP) meetings. Based on the agreement on use of L5, it was recommended that a joint paper be presented at the next NSP meeting stressing the operational benefit to be gained on incorporation of L5.

Information exchange and lessons learned on SBAS development has been a focal point for the IWG. With the transition from SBAS development to SBAS operations for both the EGNOS and MSAS systems now on the horizon, the IWG

discussed looking more closely at the areas of SBAS operations. Operating an SBAS for safety of life applications requires necessary proof documenting the safety of the system. In addition, a significant number of activities needs to be undertaken to enable SBAS use for civil aviation. Given the experience gained by the U.S. with WAAS, it was suggested that the FAA conduct an "SBAS Approval" workshop. This workshop would provide a forum to discuss the activities that the FAA had to undertake to commission WAAS into the National Airspace (NAS). A meeting date in June was suggested.

Finally, the group discussed some of the multi-modal uses of an SBAS. In Europe, the EGNOS project team continues to conduct studies on multi-modal applications for SBAS. The latest study focuses on the use of EGNOS and the future GNSS element GALILEO, to provide high integrity navigation data for the purpose of maritime harbor navigation. On a similar note, it was mentioned that the U.S. Department of Transportation was conducting a study on the feasibility of WAAS for maritime operations. Results of the study should be available by the end of the year.

GPS RAIM/WAAS Outage Prediction System Supports Alaska Capstone Program

by Karen VanDyke, VOLPE

The FAA established the Alaska Capstone program in 1998 in Southwest Alaska to improve air travel safety. As part of this program, the FAA approved the Chelton avionics package in February 2003 to provide three-dimensional navigation in support of the Capstone program. The Chelton aviation package includes a Global Positioning System (GPS) Wide Area Augmentation System (WAAS) receiver certified under Technical Standard Order (TSO) 145a/146a and the display system certified under various TSOs for a primary flight display. Pilots using the TSO 145a/146a certified receiver are approved to use GPS as a primary means of navigation in the Capstone region under the Special Federal Aviation Regulation (SFAR) approved by the FAA in March 2003.

Title 14 Code of Federal Regulations [CFR] SFAR No. 97 requires aircraft operators who plan to conduct these new Area Navigation (RNAV) GPS operations within Alaska to develop authorized procedures for normal, abnormal, and emergency situations unique to these operations, including degraded navigation capabilities and satellite system outages.

This application of WAAS was the first operational use of WAAS avionics and was approved before WAAS was commissioned. The introduction of special rulemaking associated with this application drove the FAA Alaskan Region Capstone Program's requirement for the notification of any predicted services outages during pre-flight planning based on the availability of GPS Receiver Autonomous Integrity Monitoring (RAIM).

RAIM is technique of monitoring GPS satellites and detecting instances when a GPS satellite is providing corrupted information that can lead to an incorrect position solution. The RAIM function is built into certified GPS receivers and requires a minimum number of satellites in view oriented with sufficient geometry in order to be used. As a result, RAIM is not always available to the user. RAIM was developed to provide GPS integrity before WAAS was developed, but WAAS provides its own built-in integrity checks. However, RAIM can be used as a back-up integrity solution in situations where WAAS is unavailable (e.g., the WAAS geostationary satellite is not visible to the user).

Since WAAS commissioning in July 2003, availability has been based on the availability of WAAS with a RAIM reversionary mode. The original requirement to support operations under SFAR 97 was to provide GPS RAIM/WAAS outage data generated by a prediction model and display it on a publicly accessible web interface which displays both en route and Non-Precision Approach (NPA) outages for the Alaskan region. The current goal is for the graphical coverage display for Alaska to be extended to the rest of the National Airspace System (NAS).

Today this model is available for Alaska. In order to develop this operational prediction capability, the model uses inputs from the GPS Master Control Station for planned satellite

maintenance and unforeseen outages to provide an accurate prediction of GPS availability. The RAIM prediction tool accesses a GPS almanac that is updated daily, GPS satellite outages, and an airfield database. Predictions are computed once per day and are updated dynamically as the predictions are calculated either on a scheduled or unscheduled basis.

Enroute and NPA availability are graphically depicted on a coverage map of Alaska. The NPA display contains a map of airfields color coded as to whether they have NPA availability over the prediction window.

The GPS RAIM/WAAS availability prediction tool is hosted on the National Aeronautical Information Management Enterprise System (NAIMES) platform. NAIMES is located at the Air Traffic Control System Command Center (ATCSCC) in Herndon, VA. GPS RAIM/WAAS predictions for Alaska are located as a link from the Pilotweb web page <https://pilotweb.nas.faa.gov/distribution/atcsc.html>. From this website, select WAAS Availability Prediction System from the Aeronautical Information header. The web page that will then be viewed is shown in Figure 1. Enroute and NPA availability for Alaska can be selected from this web page.

Figure 2 displays the TSO C145a/146a WAAS NPA Display. This display codes airport locations with NPA procedures with red, yellow, and green codes to denote whether there are current NPA outages, outages predicted for the next 24 hours, or no outages predicted for the next 24 hours, respectively.

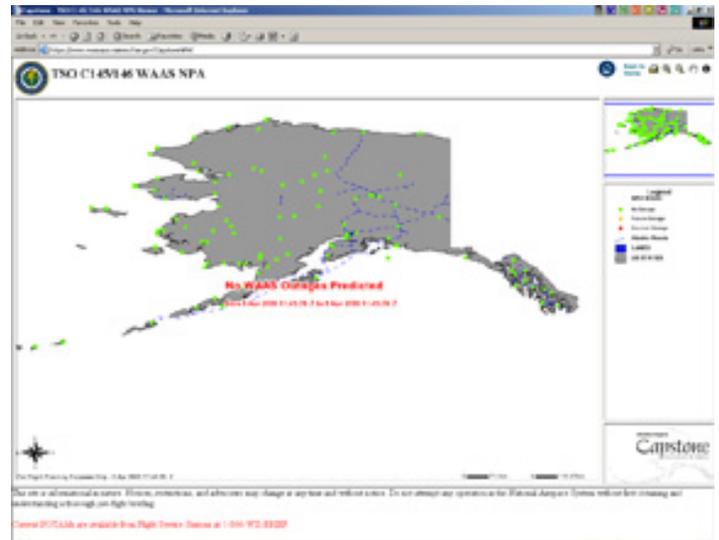


FIGURE 2: GPS RAIM/WAAS NPA Prediction

Finally, the user also has the ability to select an airfield and have a bar graph over the prediction window showing any outages. If an outage exists, the exact time of the outage will be displayed with one-minute resolution. This capability is shown in Figure 3.



FIGURE 1: GPS RAIM/WAAS Predictions for Alaska Capstone Program

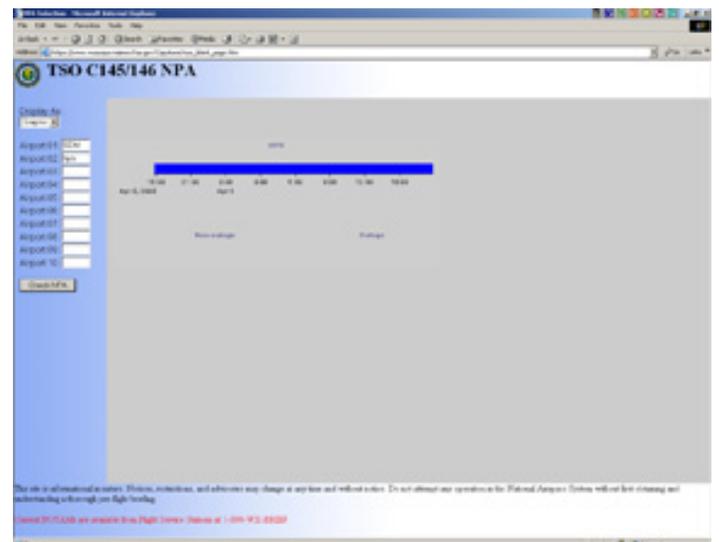


FIGURE 3: Airfield-Specific Prediction

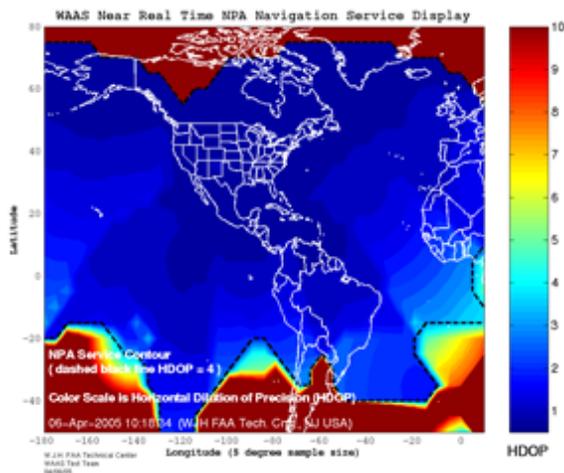
New WAAS Coverage Map Feature on Website

by **Shelby Wheeler, GPS TAC/FAA ATO-W**

As you may well know, the FAA William J. Hughes Technical Center in Atlantic City, New Jersey maintains a Vertical Protection Limit (VPL) website, which displays real-time WAAS service. However, the VPL is really only applicable to aviation applications, and has little or no relationship to the horizontal correction performance of WAAS. It is misleading to use the VPL website as a depiction of the WAAS coverage area. The VPL website is a display of the WAAS service area, where the FAA legally claims WAAS service for navigation use. This is different from the WAAS coverage area, where the signals are available but no particular service is claimed.

Due to the large and ever-increasing number of non-aviation WAAS users who access our website for information on WAAS, we wanted to more accurately display WAAS coverage. Since WAAS is being used more and more in applications such as farming, boating, hiking, and many others, the FAA William J. Hughes Technical Center has developed an additional website - a Horizontal Protection Limit (HPL) website. This site gives non-aviation users a better idea of areas that are covered by WAAS, and where better accuracies can be achieved over GPS alone.

If you haven't done so already, please access the new HPL website at <http://www.nstb.tc.faa.gov/npa.html>. You might be surprised at the size of the area in which WAAS can provide benefits to non-aviation users.



LAAS Update

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

The FAA placed the Local Area Augmentation System (LAAS) into research & development (R&D) for budget and technical risk reasons; however, the FAA still supports the development of the LAAS/Ground-Based Augmentation System (GBAS) technology. LAAS R&D focuses on solving remaining integrity and safety issues to reduce the risk for future development. The FAA GBAS Program Office will use the \$10M provided in the fiscal year 2005 appropriations to carry-out a three-pronged technical approach which is aimed at providing solutions for implementing LAAS technology.

Prong I is the completion of the integrity analysis activity for Category I LAAS. The goal is to develop a Standards and Recommended Practices (SARPS) compliant integrated prototype to validate LAAS integrity requirements by September 2006. This task is being performed under the present contract with Honeywell.

Prong II has the goal to investigate a simplified LAAS architecture with an airport monitor concept that uses WAAS-provided positioning information and locally monitored integrity. This local airport monitor could provide service to airlines through LAAS VHF Data Broadcast (VDB), however, this concept is only applicable for aircraft within SBAS LPV-coverage. The program office is presently evaluating the feasibility of this concept. This work is being conducted with the FAA William Hughes Technical Center, MITRE, Universities and the LAAS Integrity Panel (LIP).

Prong III deals with Radio Frequency Interference (RFI). The GBAS program office will prepare an analysis of GBAS-based landing system technology, prepare a risk/vulnerability assessment and determine the criticality of backup requirements. The team will evaluate technical and operational mitigations to RFI with cooperation from MITRE and several universities supporting the GBAS Program Office.

LAAS operational implementation activities are currently limited to planning for future procedure development. Industry and user support for LAAS is still strong and users are look-

ing at different options for early integration of LAAS capabilities into their plans and operations.

GBAS Working Group Meeting - Malaga, Spain

by Dieter Guenter, GPS TAC/FAA ATO-W

In June, Aeropuertos Españoles y Navegación Aérea (AENA) hosted the third GBAS working group meeting in Malaga, Spain, where AENA has a Honeywell Special Category I (SCAT I) installed.

The GBAS working group is an international working group with members from EUROCONTROL, various service providers (Australia, Germany, Spain, UK, Switzerland), European and American avionics industry, airline representatives, Boeing and Airbus. At this last meeting in Malaga, representatives from Norway and Russia joined the working group for the first time.

GBAS meetings are held twice a year at alternating locations and support the development and implementation of LAAS/GBAS technology internationally. The working group meetings serve the purpose to discuss national and international GBAS acquisition plans, areas of cooperation, technical and operational discussions in areas like GBAS integrity analysis, cooperation on ionospheric data collection and threat model analysis, operational safety assessments, early operational implementation activities and GBAS siting criteria.

The Malaga meeting provided an excellent venue for technical interchange between all participants on their plans and activities. Many countries continue to support the implementation of GBAS and presented their national plans for GBAS. Service providers from Australia, Germany, and Spain are considering investing resources to develop and approve a GBAS capability in the 2007-2008 timeframe. Australia, Germany and Spain are discussing the possibility of establishing cooperative agreements with the FAA regarding the exchange of technical data needed to support their development and approval activities.

Boeing and Airbus presented a joint briefing and provided updates of their current GLS activities. Qantas Airlines has

already ordered GLS capable B737 and A380 aircraft. Boeing and Airbus underlined the importance of early operational experience with GBAS CAT I on the path to GBAS CAT II/III.

FAA and EUROCONTROL will continue cooperative activities and information exchange for GBAS integrity, GBAS siting, ionosphere, concept of operations, GNSS failure simulation plans (EUROCONTROL activity), and the use of common validation tools.

Local Airport Monitor Concept Being Evaluated

by Ted Urda, FAA ATO-W GPS Ground-Based Augmentation Group; Navin Mathur and Ranjeet Shetty, GPS TAC/FAA ATO-W

Last fall, a previously considered (and subsequently discarded) WAAS monitoring concept was revisited. The concept involves monitoring the WAAS performance locally at an airport as a means to support and justify full 200 feet decision height Category I operations. The earlier approach considered was targeted strictly as sub-system to support WAAS Category I. Recently however, a new variation of the WAAS monitor concept has been conceived in which the monitored WAAS differential corrections are translated to the LAAS Interface Control Document (ICD) format and broadcast via the LAAS VHF Data Broadcast (VDB). This new twist has breathed new life into this previously discarded monitor concept. The new approach has since been coined the Local Airport Monitor, or LAM.

Last fall, the LAM concept was introduced at the December 2004 GNSS Strategic Advisory Team (GSAT) meeting. After considering the LAM's merits, the membership agreed that it should be investigated to further assess its feasibility. This decision served as the genesis for what is now the LAM R&D effort.

As name suggests, a LAM is a collection of monitoring equipment installed locally at a given airport (and necessarily within the WAAS coverage volume). The LAM makes local GPS ranging measurements, applies the WAAS differential correc-

tions and monitors the local performance of the WAAS at the local airport. The LAM monitoring threshold is set to ensure Category I performance is achieved.

Since the LAM broadcasts its messages in the standard LAAS ICD format, existing LAAS-certified avionics can receive and utilize the LAM's signal without modification. This is one of the key potential benefits of the LAM effort.

LAM researchers have recently analyzed collected data to assess the local navigation system error (NSE) performance of WAAS at different locations in the continental United States. It was observed that the WAAS Vertical Protection Level (VPL) is very conservative by as much as a full order of a magnitude at times when compared to the local error performance on nominal ionospheric activity days and a large portion of stormy ionospheric days. Thus, the idea of LAM emerged to take advantage of the very accurate WAAS NSE performance at local airports, and along with a moderate level of monitoring, achieve Category I level of performance. Besides the obvious benefit of achieving Category I level performance using WAAS-based GPS corrections, other benefits of LAM may include: a) reduction in development and maintenance cost, b) air carriers use of service using LAAS VDB with no changes to the avionics architecture, c) higher availability than conventional LAAS during ionospheric storms, and d) ease of certification.

Currently, two methods of implementation of LAM are being pursued. The first method is to utilize position domain monitoring to eliminate satellite geometries that may potentially cause hazardously misleading information in the aircraft. The second method monitors the satellites in the range domain and modifies the safety parameters to achieve the safety requirements of the system. Neither of these methods requires any changes to the existing avionics standards such as RTCA LAAS ICD (DO-246B) and RTCA LAAS Minimum Operational Performance Standards (DO-253A).

Currently, both of the LAM methods have shown promise. One of the LAM methods has been validated using actual WAAS data. Flight test with actual implementation of the LAM method is scheduled by the end of the fiscal year 2005. The feasibility will be demonstrated using the existing LAAS Test Prototype at the FAA Technical Center in Atlantic City. Key participants in the development of LAM are the FAA

Technical Center, MITRE, Stanford University, Ohio University, Illinois Institute of Technology, and folks on the GPS Technical Assistance Contract.

Boeing Delivers LAAS Capable Aircraft

Excerpt from <http://gps.faa.gov> (LAAS Current News)

On May 12, 2005, the Boeing Company delivered the first commercial airliner equipped to use the Local Area Augmentation System (LAAS). As LAAS ground systems become available at airports, aircraft equipped to use LAAS, such as these new 737s, will be able to operate more efficiently and safely in the terminal area in all visibility conditions. LAAS will offer very precise guidance to aircraft, eventually providing guidance all the way to the runway surface even when visibility is near zero. For more information on this new aircraft, please see the Boeing press release at

http://www.boeing.com/news/releases/2005/q2/nr_050512g.html

Corrections/Clarifications

"WAAS – A Pilot's View" article from the January 2005 SatNav News – The definition of VOR should have read "Very High Frequency (VHF) Omnidirectional Range". Our apologies to the author, Mr. Oliver, and to our readers for the error made during final editing.

"FAA LAAS and European GBAS Working Group Meeting" article from the January 2005 SatNav News – AENA noted that "Air France" should have read "AIRBUS FRANCE". – submitted to SATNAV News by AENA spokesperson.

Coming up in the next edition of SATNAV News...

Performance-Based Navigation
Progress of WAAS Service Enhancements



Federal Aviation Administration
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<http://gps.faa.gov>