GROUND BASED AUGMENTATION SYSTEM (GBAS)

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The work describes the new generation of navigation for precision approach. It contains detailed information about area navigation and Ground Based Augmentation system called GBAS. It shows the present GBAS systems in Europe. summarizes all the information about these systems, highlights the advantages and shortcomings.

Keywords: GBAS, VHF, ILS, Europe, Malaga, Bremen, SCAT-1, LAAS

1 INTRODUCTION

The work describes the new generation of navigation for precision approach. It contains detailed information about area navigation and Ground Based Augmentation system called GBAS. The work informs about older versions of these new systems. The work summarizes all the information about these systems, highlights the advantages and shortcomings.

2 GROUND BASED AUGMENTATION SYSTEM (GBAS)

The Ground-Based Augmentation System (GBAS) is a safety-critical system that augments the GPS Standard Positioning Service (SPS) and provides enhanced levels of service. It supports all phases of approach, landing, departure, and surface operations within its area of coverage. The current Instrument Landing System (ILS) suffers from a number of technical limitations such as, VHF interference, multipath effects (for example due to new building works at and around airports), as well as ILS channel limitations.

The U.S. version of the Ground Based Augmentation System (GBAS) has traditionally been referred to as the Local Area Augmentation System (LAAS). The worldwide community has adopted GBAS as the official term for this type of navigation system. To coincide with international terminology, the FAA is also adopting the term GBAS to be consistent with the international community. GBAS is a ground-based augmentation to GPS that focuses its service on the airport area (approximately a 20-30 mile radius) for precision approach, departure procedures, and terminal area operations. It broadcasts its correction message via a very high frequency (VHF) radio data link from a ground-based transmitter. GBAS will yield the extremely high accuracy, availability, and integrity necessary for Category I, II, and III precision approaches, and will provide the ability for flexible, curved approach paths. GBAS demonstrated accuracy is less than one meter in both the horizontal and vertical axis.

The operational benefits of GBAS:

- One GBAS Ground Station will be able to support multiple runway ends;
- Flight Inspection and maintenance requirements should be reduced compared to ILS;
- More stable signal, and less interference with preceding aircraft.

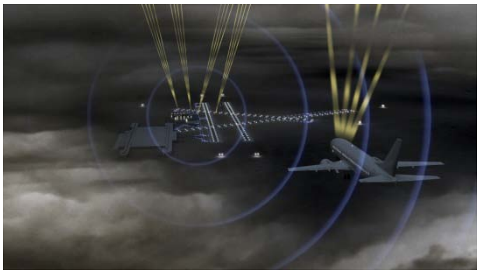

Figure 1 Illustration of GBAS

ILS and MLS have high operating costs and must be deployed at each runway end. They also have significant operational limitations, notably on airport throughput, in low visibility conditions. A move from ILS to GBAS would:

- Improve airport capacity in low visibility conditions by providing additional landing slots;

- Reduce installation costs - only one GBAS system is required per airport;
- Reduce maintenance costs;
- Allow alternate approach paths and displaced thresholds;
- Support cost-efficient use in complex runway situations;
- Eliminating interference from aerodrome movements;
- Use of the same navigation signal for all phases of flight

This transition needs to be considered and based on the MLS migration experience, a more step-wise approach for PA has been decided. This phased approach is to develop and implement GBAS CAT I as an ILS look-alike and then build on the experienced gained. Improved flight efficiency and airport operation flexibility will be provided when GBAS CAT III is achieved.

Master station of GBAS

Master Station or Processing Station is a complex collection of hardware and related interfaces driven by a custom software program.

Master station hardware (concept)

The Master Station (or processing station) consists of an industrialized Central Processing Unit (CPU) configured with a Unix type real time operating system. The CPU is configured with a SCSI I/O card for mounting an external hard drive. This hard drive collects all raw reference station GPS data messages in parallel to the processing of those messages. The drive is also used to collect debugging files and special ASCII files utilized to generate the plots found in this report. These collected files are used for component and system level performance and simulation post processing. The CPU is also configured with a multi-port RS-232 serial card to communicate in real time with the four reference stations and to the VDB. The reference stations continuously output raw GPS messages to the CPU at a frequency of 2 Hz. Data to and from the reference station fiber lines is run through media converters (fiber to/from copper), which provides a RS-232 serial signal to the CPU's multi-port serial card. The CPU then generates the LAAS corrections and integrity information and outputs them to the VDB. The VDB Transmitter Unit (VTU) is capable of output of 150 watts and employs a TDMA output structure that allows for the addition of auxiliary VDBs (up to three additional) on the same frequency for coverage to terrestrially or structure blocked areas. The LTP's VTU is tuned to 112.15 MHz and its output is run through a band pass, and then through two cascaded tuned can filters. The filtered output is then fed to an elliptically polarized three bay VHF antenna capable of reliably broadcasting correction data the required 23 nautical miles. Surge and back-up power protection is present on all active master station components.

Main station software (concept)

Ohio University (OU) originally developed the LAAS code through a FAA research grant. Once the code reached a minimum of maturity, OU tested and then furnished the code to the FAA (circa 1996). It was developed using the C programming language under the QNX operating system. QNX was chosen because of its high reliability and real-time processing capability. This LTP code has been maintained by the LAAS T&E team since that time and has undergone numerous updates to incorporate evolving requirements and hardware. The current internal master station software version is 3.0. The code stores the precise survey data of the four LAAS reference station antennas (all RRA segments). The data structures are initialized, input files are opened, and the output files are created. Messages are received via four serial RS-232 connections, which are connected to four GPS receivers. The program cycles through the serial buffers and checks for messages, if one is found it gets passed to a decoding function. From there it is parsed out to functions according to message type and the information from the messages will be extracted into local LTP variables. Once the system has received sufficient messages the satellite positions are calculated in relation to the individual reference receivers. Next the system corrects the phase center measurements for the stacked dipole antenna array and converts the measurements from the individual reference locations to one simple reference location. Then the integrity and protection equations are processed which produces the alert levels for the LGF. Next the position solution and reference position is calculated. Messages are then encoded and sent to the VDB via a RS-232 connection. Each of the three message types are encoded separately and sent according to DO-246B standards. The final step in the LGF software is to update the graphics and respond to the user inputs. At this point the software checks for problems that could have occurred during the processing and will either stop the program, or restart the cycle by reading the serial data.

Reference stations

There are four reference stations included in the FAA's LTP as required in the LAAS specification. PANS-OPS and Annex 10, requires the same number of reference stations.

Ground based performance monitoring

There are two major monitoring tools that provide an instantaneous performance indication, as well as post data processing capability. Raw monitoring station data collected is useful for observing variations in the differential position since the position can be compared to the survey position of the fixed GPS antenna incorporated into the GBPM systems. Also, it provides a continuous position calculation reference in the absence of actual flight-testing. The Ground based performance monitoring consist of :

- Multi mode receiver monitoring station
- Flight user platform monitoring station
- IONO station

GBAS coverage

The minimum coverage volume to support GBAS Cat I precision approach is defined in ICAO Annex 10, 7.3, as follows:

Laterally – Beginning at 135 m (450 ft) each side of the Landing Threshold Point (LTP) and projecting out 35 degrees either side of the final approach path to 28 km (15 NM) and 10 degrees each side of the final approach path to 37 km (20 NM).

Vertically: within the lateral region, up to the greater of 7° or 1.75 times the promulgated glide path angle (GPA) above the horizontal with an origin at the Glide Path Intercept Point (GPIP) and 0.45 GPA above the horizontal or to such lower angle, down to 0.30 GPA, as required to safeguard the promulgated glide path intercept procedure. This coverage applies between 30 m (100 ft) and 3000 m (10 000 ft) Height Above Touchdown (HAT).

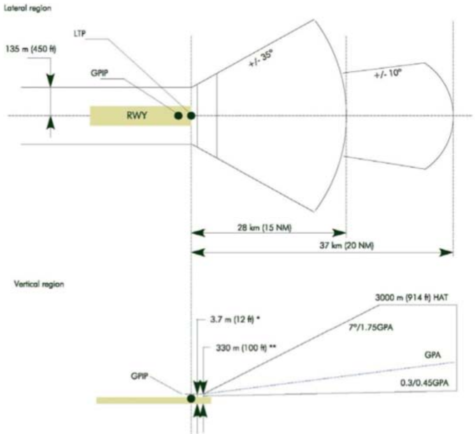

Figure 2 GBAS Coverage Volume (Annex 10)

3 SYSTEM GBAS IN EUROPE

The current EUROCONTROL GBAS activities are coordinated and directed by the EUROCONTROL "Landing and Take Off (LATO)" Focus Group with representatives of the EUROCONTROL stakeholders, including aircraft manufacturers, airlines, air traffic service providers, certification authorities and other parties. The LATO groups treats all aspect of Precision approach and Landing, including those related to ILS and MLS, but mainly focuses on GBAS. It addresses operational, safety and technical aspects. GBAS activities are also coordinated with FAA activities in this area in the recently formed FAA-Europe "GBAS Working Group". This group, with recent additions of representatives from Russia and Australia provides a forum for information exchange covering all aspects of technical, operational and safety elements of GBAS introduction and can be seen as a GBAS equivalent to the Interoperability Working Group (IWG) active between SBAS providers. In both groups, aspects of GBAS CAT I introduction, which is seen as a necessary step towards the final goal are treated in detail, while progress toward GBAS CAT II/III is limited to the activities supporting and complementing operationally ICAO, RTCA and EUROCAE standard developments.

There are a number of GBAS or GBAS like systems in Europe. Some of them are going to be tested, planned or just representing the predecessor of these systems (SCAT-1).

List of airports equipped with GBAS or SCAT-1, being tested or just planning to implement it:

Figure 3 GBAS and SCAT-1 systems in Europe

Spain - AENA
- Malaga
- Las Palmas

France - DSNA
- Toulouse

Italy
- Palermo

Deutchland - DFS
- Bremen
- München
- Frankfurt (Egelsbach)
- Braunsweig

Norway - Avinor - SCAT-1
- Bronnoysund
- Hammerfest
- Namsos
- Vadsoya
- Baatsfjord
- Svolvær

Malaga airport

Aena started its GBAS CAT I Programme in the late90s. By means of carrying out the installation of several GBAS Ground Station Prototypes, Aena's Satellite Navigation team has had the opportunity to acquire the experience and know-how to continue working towards a certifiable CAT I system installation. Therefore and after the complete technical development of the new SLS-4000 system and its installation in Malaga Airport, Aena is facing up to the last step of the way to make GBAS become a reality: the Operational Implementation phase.

In this sense Aena and some Airlines (Air Berlin, Thomson) are working together to promote the operational implementation at Malaga, and in the near future in other Spanish Airports.

Currently Air Berlin is playing a key role by monitoring GBAS performances in their regular approaches to Malaga Airport, and reporting their results. In addition to these activities Aena keeps collaborating with other stakeholders worldwide(FAA, JACB, DFS).

Figure 4 GBAS systems at Malaga airport

Airport Malaga is on list of 25 biggest airports in Europe, it is the fourth biggest in Spain. The new terminal will double the number of passangers. Malaga will get a new runway, and new apron will be built. In 2012 Malaga will be the second certified airport for GBAS CAT I approaches in Europe.

Bremen

Airport in Bremen is located in northwest Deutschland. There were more than two and a half million passangers in 2011, and airlines like Lufthansa, Germanwings, Air Berlin, Ryanair, KLM, and any other seasonal charters, and private business jets.

In 2009 SLS-4000 Honeywell GBAS was installed at the airport. The system had been tested before installing Smart Path system, so the airport participated in the development of these systems. After installation of the whole system, the system was being tested by Air Berlin, lot of institution, government, etc. The main support was given by Air Berlin. This airline is giving most support for implementation of GBAS in the world. They main objective is to get GBAS to most used airport in the world. Air Berlin carried more than 33 million passengers over the world, behind Lufthansa Air Berlin is the second biggest airline in Deutschland. The average age of they aircraft is 5 years.

Airlines prefer the system GBAS, because of reducing the costs for flight, emissions, noise and a modern concept, which fits to the concept of modernisation of Eurcontrol, FAA, and any other civil aviation authorities.

Bremen was the first airport certified for CAT I GBAS, and they are using it as main navigation system for precision approach. The certification process ends with first certified flight on 9 February 2012.

Figure 5 The crew of first certified flight using GBAS 09.02.2012

Norwegian SCAT-1 Airports

There is nine international, nine medium sized, and 28 regional airports with around 800 m long runway, with VOR/DME or LLZ/DME nav aids, and other military or private airports. These regional STOL-ports have a number of disadvantages : non precision approaches, black hole effect, many circling, non radar uncontrolled environment. These negative effects causes some CFIT accidents. There was two big accidents in 1988 and 1993 when Dash 7 and later DHC-6 crashed. First plane collided with mountain when missed a step down fix, second crashed before runway due to black hole effect. In 1996 Norwegian Parliament reacts with decision to install electronic glide paths to STOL-ports. The decision was made to install DGPS, SCAT-1 concept. In 1997 they are only proved the concept, in 1998 started the pre-implementation phase, and in 2001 the test flights has begun. And the future looked bright. In 2005 there were first certification flights at ENBN airport. All flights were successful, and the accuracy was unprecedented.

In October 2007 Brønnøysund was inaugurated and it was worlds first airport with certified SCAT-1 approach. Hammerfest was operational in 2008, so the phase of implementation, installation begins, and we see on Figure 3 there are a lot of STOL-ports with SCAT-1 in Norway in 2012.

Figure 6 SCAT-1 flight test team with two Bombardier Dash 8 in the background

4 CONCLUSION

I hope, that this review, document provided you all the information, that you expected to get from it. It described the Ground based Augmentation System on these six pages as good as i can. It shows the coverage volume of this system as it is defined in Annex 10, and PANS-OPS. It collects the information about these system in operation in Europe.

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