PRECISION APPROACH FOR LANDING USING SATELLITE NAVIGATION SYSTEMS ON A SELECTED AIRPORT

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The content of this thesis is the description of satellite navigation systems and their utilisation in the final phase of flight. Basic satellite navigation systems, principles of their operation and augmentation systems are analysed in this thesis. The thesis is focused primarily on using these systems for precision approach landing and the GBAS system, which provides this feature. The principle of operation of the GBAS system at Bremen airport and a draft of implementation of the GBAS system at Prague airport are described in the thesis.

Key words: GNSS, GPS, GLONASS, GBAS, augmentation systems, precision approach, implementation, avionics, navigation, satellite

1 INTRODUCTION

Development of sattelite navigation systems began at the verge of the 50s and 60s years of the last centrury. The history of the two most famous and most successful sattelite navigation systems, GPS and GLONASS, started to form at that time already.[2],[3] In the airline industry, these systems were originaly used as orientational, or in cases as back up systems for flying a plane. Thanks to new and perspective technologies, combination of core GNSS constelations and their augmentation systems are being now used in precision approach, so with the last phase of the flight, which is one of the most important phase in the aspect of security.[4],[5]

The GBAS system is a global sattelite positioning system with a surface augmentation and is meant to take the the aging ILS system´s place. The ICAO organisation, Eurocontrol and FAA marked the GBAS as a tool for streamlining the process of air traffic management. Even if this system is already been installed at many airports round the world, it is still at the testing and development state.

2 GNSS

GNSS comprises the core constellations (GPS and GLONASS), GNSS receivers, ABAS, GRAS, SBAS and GBAS.

2.1 Basic satelite constelation

This is, together with the receivers, the basic part of the GNSS. According to Annex 10, two core satellite constellations have Standards and Recommended Practices (SARPs) incorporated: the GPS from United States of America and the GLONASS from the Russian Federation. There are two other constellations under development: GALILEO (European) and COMPASS (Chinese).

GPS and GLONASS have the capability to provide accurate position and time information worldwide. The accuracy provided by both systems meets aviation requirements for en-route through non-precision approach, but not the requirements for precision approach.

Considering the importance of the core constellations, according to Annex 10, any change in the SARPs that requires the replacement or update of GNSS equipment require a six-year advance notice. Similarly, a six-year notice is required of a core or augmentation system provider who plans to terminate the service provided.[1]

2.2 Augmentation Systems

Even though the core constellations and the receivers can provide accuracy, continuity, availability and integrity to meet from en-route to non-precision approach (NPA) requirements, for precision approach and procedures that require a greater degree of accuracy or integrity, it is necessary to have some source of augmentation for these parameters. The augmentation systems that are listed in Annex 10 SARPs are ABAS, GRAS, SBAS and GBAS and will be briefly described below.

Except for ABAS, the philosophy of the other augmentation systems is based on the concept of differential correction, which uses GNSS receivers installed on the ground in a precisely defined position to calculate the error for each pseudo-range distance measured from satellites in view of the core constellations. The calculated error for each satellite is then broadcasted so other receivers can correct the information coming from the satellites.

The core satellite constellations were not developed to satisfy the strict requirements of IFR navigation. For this reason, GNSS avionics used in IFR operations should augment the GNSS signal to ensure, among other things, its integrity. ABAS augments and/or integrates GNSS information with information available on-board the aircraft to enhance the performance of the core satellite constellations. Many States have taken advantage of GPS/ABAS to improve service without incurring any expenditure on infrastructure. The use of GPS/ABAS is a worthwhile first stage in a phased transition to GNSS guidance for all phases of flight.

An SBAS augments core satellite constellations by providing ranging, integrity and correction information via geostationary satellites. The system comprises:

- a network of ground reference stations that monitor satellite signals
- master stations that collect and process reference station data and generate SBAS messages
- uplink stations that send the messages to geostationary satellites
- transponders on these satellites that broadcast the SBAS messages.

SBAS can support all en-route and terminal RNAV operations. Significantly, SBAS offers the promise of affordable RNAV capability for a wide cross section of users.

3 GBAS

The current core constellation is unable to provide accuracy, availability, continuity and integrity to achieve precision approach. GBAS uses the concept of differential corrections to augment satellites signal in order to meet these requirements. GBAS provides augmentation to the core constellations to enable precision approach up to Category III.

3.1 General description

GBAS works based on three segments: satellites constellation, ground station and aircraft receiver. GBAS ground station is formed by reference receivers with their antennas installed in precisely surveyed points. The information generated in the receiver is sent to a processor that computes the corrections for each navigation satellite in view and broadcasts these differential corrections, besides integrity parameters and precision approach pathpoints data, via a Very High Frequency (VHF) Data Broacast (VDB).

The information broadcast is received by aircraft in VHF coverage that also receive information from the navigation satellites. Then, it uses the differential corrections on the information received directly from the navigation satellites to calculate the precise position.

The precise position is used, along with pathpoints data, to supply deviation signals to drive appropriate aircraft systems supporting precision approach operations.

GBAS approach indication to the pilot is similar to the course and glide path indications of ILS.

3.2 Benefits of GBAS system

Comparing to other precision approach systems, GBAS presents lots of benefits:

- reduction of critical and sensitive areas
- curved approach
- positioning service
- provision of service in several runways in the same airport
- provision of several approach glide angles and displaced threshold
- guided missed approach
- adjacent airports use.

3.3 Development of GBAS system

GBAS was included in Annex 10, Volume 1 by Amendment 76, developed by the Global Navigation Satellite System Panel (GNSSP) from ICAO, that later became the current Navigation Systems Panel (NSP). Several government agencies, industries and universities work on the development of GBAS ground stations and aircraft receivers and on the operational implementation of the system.

Since 2004, the Federal Aviation Administration and Eurocontrol chair the meetings of the International GBAS Working Group with the attendance of Air Navigation Service Providers, Certification Authorities, Airport Authorities, Airlines, aeronautical industries, universities and others. The purpose of the IGWG is to share information regarding GBAS implementation and development.

3.4 GBAS equipment for aircrafts

The big aircraft manufacturers (Boeing and Airbus) have already implemented GBAS landing capability in several of their aircrafts. Airbus offers GBAS CAT I as an optional item for customers in A380, A350 and A320. For A330 and A340, they are still working on approval for operation. Boeing offers GBAS CAT I as an optional item in B737-NG and as a regular item in B747-8 and B787.

3.5 Considerations for GBAS implementation

The implementation of GBAS operations requires a series of activities in order to enable the accomplishment of an efficient process. The decision of installing a GBAS has effects in several areas of aeronautical community and must be preceded by a detailed analysis of the scenario. A study for identification of airports suitable for installation must be conducted followed by a Cost-benefit analysis (CBA) of the implementation. The CBA must take in consideration several items like:

- number of aircraft ready to operate GBAS
- number of aircraft operators commited with the acquisition/modernization of GBAS-capable aircraft
- statistical analysis of meteorological conditions
- evaluation of air traffic growth
- NAVAIDs existing to support nonvisual approaches
- Planning to change existing NAVAIDs
- Evaluation of the real operational requirements at the airport

4 GBAS AT BREMEN AIRPORT

With global air travel continuing to rise, airports need to find new ways to handle additional aircraft movements without incurring the costs of building more runways. GBAS has been identified by ICAO, the U.S. Federal Aviation Administration (FAA), and Eurocontrol as an enabler for improving air traffic and Honeywell’s solution, the SmartPath Precision Landing System, is the world’s only certified system. Bremen Airport in Germany was the first airport in the world to adopt the technology.

4.1 Reasons of implementation GBAS system at Bremen airport

Soaring demand for air travel means that major airports around the world are being forced to increase their operating capacity. As pressure on infrastructure increases, many airports need to maximise the number of aircraft movements that can make use of their existing runways and airspace and, at the same time, keep flight delays to a minimum – particularly when they are affected by bad weather. Additionally, in many parts of the world, airports and airlines are required to reduce the environmental impact of their operations – both in terms of noise and emissions. The FAA NextGen and Eurocontrol’s SESAR programmes have identified ground-based augmentation systems (GBAS) as an enabler for improving air traffic capacity. Honeywell is leading the way with the world’s only certified GBAS solution, the SmartPath Precision Landing System. Progressive airports, air navigation service providers and airlines are already benefiting from this next-generation precision approach and landing technology.

Honeywell's SmartPath Precision Landing System is now being installed at airports around the globe. The technology enables the airports to offer up to 26 different precision approaches using a single system and, unlike instrument landing systems (ILS) that need to be installed at the end of every runway, one GBAS can cover an entire airport's operation. SmartPath augments global positioning system (GPS) satellite data and transmits digital guidance information to aircraft that are equipped with Global Navigation Satellite System (GNSS) Landing Systems (GLS). Most modern major airline platforms have the capability to fly GBAS approaches, with future models standardised on this advanced technology. Honeywell's SmartPath Precision Landing System provides differential GPS correction and integrity for all satellites in view and approach path information covering all runway ends. Currently certified for Category I operations, SmartPath GBAS will continue to grow to provide Category II and Category III performance.

4.2 Benefits of GBAS system at Bremen airport

Bremen Airport in Germany was the first airport in the world to adopt GBAS, with a system installed for the nation's air navigation services provider, DFS Deutsche Flugsicherung GmbH. DFS identified GBAS as an eventual successor to ageing ILS technology and wanted to familiarise itself with the system. It chose Bremen Airport for GBAS operational evaluation as the airfield offered moderate levels of air traffic in a simple operating environment without high terrain. The technology has gained German-type certification as a primary landing system from the Federal Supervisory Authority for Air Navigation Services (BAF) and is now being used independently of the ILS for CAT I precision approaches.

5 GBAS AT PRAGUE AIRPORT

If we think about installation of GBAS system at LKPR, we have to consider many aspects. The major one is that at RWYs are installed ILS systems with lifetime up to the 2017 and 2022. The other important fact is based on GBAS certification which is nowadays only for CAT I. For CAT II/III it should be soon, but it could take longer time.

5.1 Possible scenario of GBAS implementation at Praha airport

GBAS installation at Prague airport could proceed according to the following scenario. Airport should install GBAS CAT II/III and renew the ILS CAT I as a back-up mean in case of loss of signal or breakdown GBAS. By the year 2017 the lifetime of ILS installed at the RWY 12/30. By this year GBAS should be certificated for CAT II/III and also the onboard equipment should be more expanded and available. So one of the optimal possibilities is to install GBAS CAT II/III in the year 2017 and not renew ILS at RWY 12/30. After that it seems to be the best option not renews the ILS system at RWY 06 and renew only the one at RWY 24R 6 as a back-up system (after the end of life time in 2022).

The total cost of GBAS installation at Prague airport according the this scenario would be 2 755 000 €. On the other hand, the total costs on renewal and operation of ILS system in years 2017 – 2027 would be 5 508 000 €. The total costs on GBAS installation could be considered as more efficient to compare it with ILS and the airport could save about 2 753 000 €.

6 CONCLUSION

Major airports around the world are forced to increase their operational capatity as a result of rapidly growing demand for air travel. Under the influence of increasing pressure on infrastructure, many airports must try to maximize the aircraft movements at their existing runways and in its airspace, and at the same time, keep flight delays to a minimum – especially at a time, when the airport is adversely affected by bad weather conditions. In addition, in many parts of the world airports and airlines are required to reduce the impact on the environment – both in terms of noise and emissions.

Solution to this situation is augmentation system of Global Navigation Satellite System, GBAS, which achieves such benefits for air traffic by its performance, that it has been adopted as a main system for precision guidance for aircraft landing by international organisations and it also represent a future alternative to a current aging system ILS. GBAS system provides operational benefits in terms of reducing enviromental impact around airports and reducing operational costs and removes restrictions, which are typical to the ILS system.

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