**Advances in Science and Technology Research Journal**
Volume 7, Issue 17, March 2013, pp. 62–65
DOI: 10.5604/20804075.1037001

*Review Article*

# EGNOS - USE OF GPS SYSTEM FOR APPROACH PROCEDURES

**Ewa Wajszczak[1], Dominik Galas[2]**

[1] The State School of Higher Education in Chełm, Pocztowa 54, 22-100 Chełm, Poland, e-mail: e.wajszczak@gmail.com

[2] The State School of Higher Education in Chełm, Pocztowa 54, 22-100 Chełm, Poland, e-mail: dominikgalas91@gmail.com

Received: 2012.11.08
Accepted: 2012.11.29
Published: 2012.12.21

**ABSTRACT**
Since GPS system became available for common use, a it has been applied in many areas, including aviation. The development of portable GPS receivers provided immeasurable aid in air navigation. The paper presents EGNOS system that ensures the possibility of using GPS system for approach procedure. The article addresses the following issues: the history of creation and development of GPS, principle of system operation, accuracy in relation for GPS system, comparison with conventional radio navigation ILS system and potential benefits from implementing EGNOS.

**Keywords:** GPS system, aviation, air navigation, approach procedure.

## INTRODUCTION

The EGNOS system, i.e. European Geostationary Navigation Overlay Service, is a pan-European satellite system which supports American GPS and Russian GLONASS. It informs about malfunctioning of compatible systems and increases the accuracy of indications from 17 m (offered by GPS) to 3 m. EGNOS belongs to SBAS group, i.e. Satellite – Based Augmentation Systems. EGNOS's range is mainly Western Europe. Its counterpart across the Atlantic is WAAS (Wide Area Augmentation System, operational since 2003), which covers the area of North America. The region of East Asia belongs to Japanese MSAS (Multi-functional Satellite Augmentation System, operational since 2007). Indian subcontinent will be equipped with GAGAN (GPS and GEO Augmented Navigation), whose full operating is planned for 2014 [2, 4, 8].

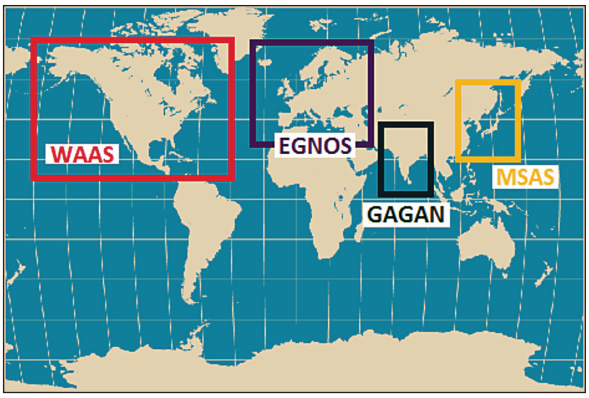


**Fig. 1.** Approximate area of operation of SBAS systems

## HISTORY OF THE ORIGIN AND DEVELOPMENT

EGNOS is a common project of European Cosmic Agency, European Comission, EUROCONTROL and European Organization for Air Navigation. This represents a major step towards the creation of global, satellite, navigation system which is currently being developed in Europe – the Galileo [9]. The beginning of EGNOS is the year 1994 when the Council of the European Union approved a project to create the system. In 1996 the first of telecommunications satellite – Inmarsat F2 AOR-E was placed in orbit. 2 years later another one – Inmarsat F5 IOR-W was sent. In June 2003 in Langen (Germany) first MCC station – Master Control Centre was opened. In July 2005 the first version of EGNOS was launched, which sends a continuous signal. A year later version 2.1 was introduced. It extended the system to cover the coast of North Africa and gave a real-time access to RIMS - Ranging and Integritny Monitoring Stations, whose most significant role is the measurement the corrections. Next versions continued extending the coverage over North Africa. the 1st October 2009 was essential for the system as it was when the Open Services were declared fully operational . A year later, the service Safety-of-life was launched, substantial for EGNOS to be used in aviation. In the nearest future it is planned to introduce v.3 to cover the MRS (Multi-Constellation Regional System).

The infrastructure of EGNOS consists of three geostationary satellites over Europe (third, not mentioned previously is the ESA Artemis, which belongs to European Space Agency) and a network of ground stations:

- 34 RIMS stations (Ranging and Integrity Monitoring Stations) – measurement and observation stations. It is worth noticing that one of them is located in Warsaw.
- 4 MCC stations, which are located in Ciampino (Italy), Gatwick (Great Britain), Longan (Denmark) and Torrejon (Spain).
- 6 NLES (Navigation Land Earth Station) – transmitting station, assigned in pairs to each satellite, located in Torrejon (Spain), Fucino (Italy), Aussaguel (France), Raisting (Germany), Goonhilly (UK) and Sintra (Portugal).
- 2 stations in Torrejón (Spain) are DVP (Development Verification Platform) and ASQF (Application Specific Qualification Facility), while in Toulouse PACF (Performance Assessment and Check-out Facility) is placed.

The complementation of terrestrial infrastructure is EWAN (EGNOS Wide Area Communications Network) – network for communication between ground components of the system [6, 8].

## PRINCIPLE OF OPERATION

EGNOS system's performance is inspired by the systems which EGNOS supports. It measures the way of the signal sent by a geostationary satellite transponders, which are moving in a particular orbit. Knowing the distance from one of the satellites we place it on a sphere with a radius (equal to that distance). Being in possession of two satellites, we place one of it in a circle, which is located at the intersection of two spheres. If we add to this the information from a third satellite, the satellite can be in one of the two resultant places. The final information is obtained by excluding the point which is moving too fast or too high.

Geostationary satellites are equipped with transponders that emit in the same way as GPS satellites – have the same frequency, but different correlation coefficients. The signal contains information about the differential amendments and any defects of transmissions.

The main task of the RIMS stations is to monitor the constellation of geostationary satellites, GPS, GLONASS, but also to provide a precise time scale for the system. There are the following types of RIMS stations [7]:

- providing corrections,
- assessing the accuracy of the navigation information,
- detection of irregularities in the signals of supported systems.

MCC Stations process the data received from the RIMS, monitor and archive the system and create corrections of WAD EGNOS. Another important function of the station is to check the reliability of the signals received by the users of EGNOS. We have mentioned the existence of four stations. Only one of them is active, while others are ready to act at any time in case of emergency.

The main task of NLES stations is communication with satellites. They send them a navigation signal modified with a code of modulation, WAD corrections and GIC (Geostationary Integrity Channel) information. They are particular

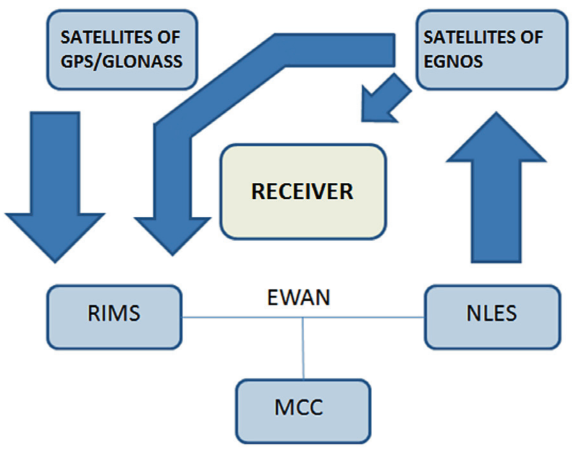


**Fig. 2.** Principle of operation of EGNOS system

about the integrity of the code and phase signals. The system offers the following services:

- The Open Service: is free of charge, but there is not any guarantee of indications. The service, launched on 1st October 2009, is available to anyone with a satellite signal receiver adapted to EGNOS.
- The Safety-of-Life Service: provides comprehensive information, not only about the position, but also malfunctioning of the GPS signal within 6 seconds. The service meets the requirements of ICAO, hence it has been used in civil aviation since 2011. We can distinguish two segments which are applied respectively for NPA - Non Precision Approaches and APV – Approaches with Vertical guidance.
- The Commercial Service: EGNOS Data Access Service (EDAS) is a chargeable service that allows access to data collected by EGNOS's infrastructure.

## THE ACCURACY OF THE SYSTEM IN COMPARISON TO THE GPS

Originally GPS had two levels of access: civil and military. For political reasons a method of signal interference (SA) Selective Availability was introduced, it limits GPS accuracy down to 100 m. In year 2000 the president Bill Clinton put an end to the SA mechanism, which was an interfering ephemeris of satellites and atomic clock corrections, so the positioning accuracy for ordinary users has increased to about 4 – 17 meters horizontally and 37 meters vertically. These parameters are still below the expected level. The reason is that the orbits of the satellites are fluctuated. This is called by the so-called ephemeral error. The accuracy of GPS base system is also under negative influence of radio signal interference due to heterogeneity of the atmosphere. Another factor in the intensification of error is the drift of GPS satellite atomic clocks.

The errors of the assisted systems are of equal value in a particular area. Locating the RIMS stations in places with specific coordinates, we can measure the error of current indications, the calculation of the correction and to send it to mobile receivers, either directly or through satellites. As a result, according to the data published by the administrators, the accuracy of EGNOS is up to 3 meters horizontally and up to 4 meters in height. Reliability is estimated at 99%

## COMPARISON EGNOS – ILS

Considering use of EGNOS for approach procedures it is impossible not to mention the comparison with traditional radio navigation system used for that purpose – the ILS. The first criterion for comparison are the operational minimums for both systems. Considering the ILS Cat I the decision height – DH – is 200 ft (60 m). By using the EGNOS system we can comply APV procedure (approach procedure with vertical guidance) with the minimum descend height of 250 ft (~76 m). As a conclusion we can say that both procedures have similar minimums. Although, it is remarkable to say that in both cases special airport facilities (e.g. runway landing lights) are necessary for the mentioned minimums.

Another criterion of division is the credibility of both systems – taking the use of both systems in aviation into consideration, credibility is as important parameter as operational minimums. For ILS Cat I system, time to alert – the time for informing the user about lack of data with expected accuracy - is 6s. In case of standard GPS the same time could be as long as approximately 2 hours and that makes standard GPS useless for approach procedures. By using EGNOS system this time can be shortened to about 6 s – time which correspond of time to alert of ILS.

Subsequently, it is worth to take a closer look at accuracy of guidance in both systems. In case of EGNOS system – APV approach – we obtain the accuracy of horizontal guidance of 16m and of vertical guidance of 20 m. For ILS Cat I the same values are as follows: 16 m and 6 m. It is easy to notice that ILS has more than three times higher accuracy in vertical guidance [3]. Although, it is worth mentioning that results of experimental measurements of accuracy of EGNOS system, that were conducted by Polish Air Navigation Services Agency, demonstrated a significantly greater precision: approximately 2 m of both horizontal and vertical guidance. Judging from that results we can say that potential capabilities of EGNOS system can meet demands of system even more accurate than ILS Cat I.

The last criterion of comparison would be the equipment requirements of both systems [1, 4, 5]. For ILS system these are: suitable ground installation – the localizer and glide path transmitter and airborne equipment – cross deviation indicator CDI. For EGNOS airplane has to be equipped with certificated receiver of SBAS signal (Satellite Based Augmentation System – European equivalent of SBAS is EGNOS) and also CDI. As mentioned before, in both cases special airport facilities are also necessary. Actually, airport facilities are in many cases determining factors for airport operational minimums that could be set during designing of APV procedure. Taking into account FAA ( Federal Aviation Administration ) regulations we will notice that for an airport to have the minimums similar of those of ILS system, it is necessary to have exactly the same facilities as for ILS system. Simultaneously, lack of such facilities does not exclude the possibility of creating APV procedure, it only increases the values of meteorological minimums. The conclusion that could be stated automatically after the last comparison is a significant difference in operation cost of both systems. Mainly, this is the reason for such a rapid development of navigation systems relying on GPS systems.

Comparing both systems it is important to notice a potential future evolution of satellite systems resulting in higher accuracy in position indications. Observing the actions of FAA we can notice constant pursuit for the improvement and implementation of LAAS system (Local Area Augmentation System, one of Global Based Augmentation Systems). Principle of operating this system is similar to EGNOS system excluding the area of operation. By FAA assumptions LAAS will provide the increase in accuracy of position indicating to about 0.5 m in the area within the radius of 45 km from ground station. With the use of this system FAA plans to develop approach procedures with minimums identical with ILS Cat III. The system mentioned is still at the testing phase and the actual date of implementation of procedures using it is not known yet.

## POTENTIAL BENEFITS FOR IMPLEMENTATION OF EGNOS SYSTEM

It seems to be impossible to list all the benefits that could be obtained from the prevalence of EGNOS system. The following list presents the most important ones [10]:

- Increase in safety of the conducted aviation operations. According to the forecasts of airlines and Air Navigation Agencies decrease in CFIT (Controlled Flight Into Terrain) accidents could be as high as 75%.
- Reduction in cost of operations of airlines due to decrease in number of delays, diversions or cancelled flights. This should result in the reduction in ticket costs and this is a direct benefit for passengers.
- Reduction in operating costs for airports. Maintenance of ILS system is associated with expenditure of hundreds of thousands euro each year. Due to creating approach procedures with the use of EGNOS airport can generate huge savings.
- Possibility of creating APV procedure for airports where using of ILS system is not economically justified. It increases the rank of the airport and gives possibility for operations in bad weather conditions.
- A lot of new possibilities in creating approach procedures. It became practicable to respect noise abatement procedures more strictly.
- Better use of airspace in general. It will help in general development of aviation.

## REFERENCES

1. Domicz J., Szutowski L. Podręcznik pilota samolotowego. Poznań 2006.
2. EGNOS: European Geostationary Navigation Overlay Service. ESA Communications Production, European Space Agency 2009.
3. Felski A., Banaszek K., Woźniak T., Zakrzewski P. Dokładność serwisu EGNOS w kontekście obsługi operacji lotniskowych. Zeszyty Naukowe Marynarki Wojennej, LII, 1(184), 2011.
4. Radio-Navigation. Jeppesen Sanderson, 2004.
5. Kusek K., Bugajski W. System EGNOS – zastosowanie praktyczne w lotnictwie ogólnym.
6. Oficjalna strona systemu EGNOS: http://www.egnos-portal.eu, 20.10.2012.
7. Rutkowski A., Setlak M., EGNOS to działa. Przegląd lotniczy, 4, 11.
8. Strona Europejskiej Agencji Kosmicznej: http://www.esa.int/esaNA/egnos.html, 20.10.2012.
9. Ventura-Traveset J., Flament D. EGNOS, the european Geostationary Navigation Overlay System – Cornerstone of Galileo. ESA, Noordwijk 2006.
10. Zieliński J.B., Jaworski L., Krywanis M. EGNOS: Stan obecny i perspektywy rozwoju. Zakład Geodezji Planetarnej, Centrum Badań Kosmicznych PAN.