EGNOS NEWS

Volume 3, Issue 1, February 2003

Contents

Stop Press!

- ESTB signal structure changing to be compatible with WAAS. Announcement imminent. See www.esa.int/navigation
- ARTEMIS satellite now in geostationary orbit

Editorial

Happy New Year and welcome to ESA's newly renamed "EGNOS News"! 2003 is going to be an important year for EGNOS as we move towards the start of operations in April 2004. EGNOS ground infrastructure is currently being deployed around Europe, and the system will go "live" this year with the first true EGNOS signals. Listening to comments at the ESTB Workshop last November underlined just how widespread the use of EGNOS will be when it becomes operational.

In this issue you will read about SBAS interoperability and what this means for you as a user. You will also hear how EGNOS can be used to improve the Helicopter Emergency Service in Europe by delivering operational efficiencies and, crucially, saving lives. We also highlight recent flight trials in Cairo, Egypt, that demonstrate how EGNOS services can be extended to the Eastern Mediterranean.

All of us at ESA's EGNOS Project Office wish you every success for 2003.

SBAS Interoperability Explained: Delivering A Global Service

Satellite-Based Augmentation System (SBAS) is the generic term for systems like EGNOS that are also being developed in the US, Japan and elsewhere.

In previous articles we have concentrated on issues associated with EGNOS and the EGNOS System Test Bed (ESTB). But EGNOS is more than just a European regional SBAS that augments GPS – it is the European component of a global initiative that aims to deliver a global, seamless, safety-of-life navigation service. So, in this issue, we are going to talk about the other SBAS systems, and how they are used to augment GPS, and we will see how interoperability between them brings benefits to users.

Why should I be interested in systems other than EGNOS?

Let's remind ourselves about what SBAS systems do. Each broadcasts a GPS look-alike signal modulated with Wide Area Differential (WAD) and integrity data from dedicated geostationary satellites. If you are in the European EGNOS coverage area with an SBAS receiver, you will track at least two additional GPS look-alike signals and these will improve positioning availability. You will also receive and use the WAD and integrity data. The former will improve positioning accuracy, while the latter improves quality of service and is important for safety of life users.

So, why should you be interested in SBASs other than EGNOS?

Well, firstly, if you find WAAS-compatible rather than EGNOS-compatible receivers in the shops, you may want to know whether these will work with EGNOS. Secondly, your receiver might track GPS look-alike signals from other SBASs, particularly if you are near the edge of the EGNOS coverage area (e.g. the European Atlantic coast). Should you use these satellites and are their WAD corrections valid in Europe? Finally, will your SBAS receiver work normally if you travel outside Europe? These questions are answered later on.

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To the Emergency Room with EGNOS

Last year we reported on the first helicopter trials, telling you how EGNOS had passed stomach-churning helicopter flight trials with flying colours. In this issue we are going to look at how EGNOS can be used to improve the efficiency of the Helicopter Emergency Service (HEMS).

In Western Europe today, 125 operators (civil and public) run 450 HEMS helicopters. They have two distinct missions: transport from the scene of an accident

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HEMS: A Vital Safety Service

Cairo Flight Trials

In September 2002, three reference and integrity monitoring stations (RIMS) were added to the ESTB to provide eastern Mediterranean coverage for EGNOS flight trials at Cairo, Egypt. These tests were conducted by the Italian ATS Provider, ENAV, in cooperation with Telespazio and the EGNOS Project Office.

These Cairo flight trials were first discussed in March 2000 at an ICAO Middle East Air Navigation

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Cairo Flight Trials: *(continued from front cover)*

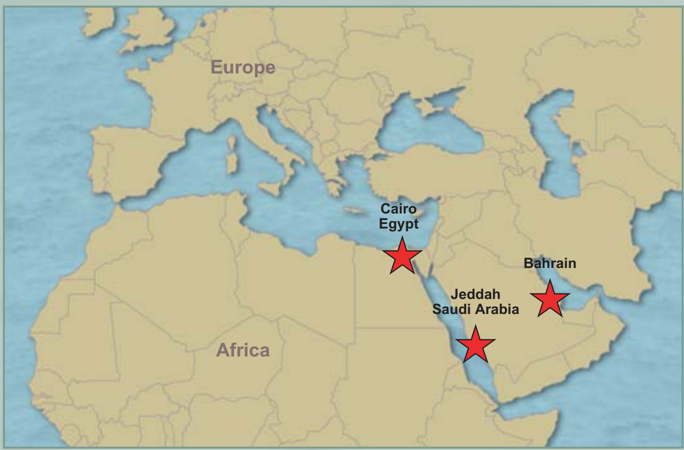
Planning and Implementation Regional Group (MIDANPIRG) GNSS task force meeting. The objectives included demonstrating EGNOS compliance with International Civil Aviation Organisation (ICAO) requirements for APV-I and APV-II over the eastern Mediterranean, and validating methods for extending EGNOS services beyond the European Civil Aviation Conference (ECAC) region.

As part of the preparation for these trials, the ESTB was combined with the Mediterranean Test Bed (MTB), and three additional transportable RIMS were deployed in Cairo, Jeddah in Saudi Arabia, and Bahrain. A pre-operational EGNOS signal was broadcast from Inmarsat's Indian Ocean Region satellite, and a Cessna Citation SII aircraft was equipped with advanced flight inspection instruments, EGNOS receivers and special flight data recorders for use during these trials.

Between October 7 and 11, the Cessna performed around thirty ILS look-alike precision approach procedures at Cairo on Runway 05R and Runway 23L. These were performed at different times of day to assess the impact of the ionosphere. The ESTB was also trialed in an en route environment using straight and circular tracks within 50NM of Cairo airport.

So, how well did the ESTB perform? Anecdotal evidence from the pilots indicated they were confident that the ESTB was complying with APV-II precision approach requirements. We were also pleased to hear that the IOR satellite was always visible, even during non-standard turns with 60° banking.

These early results look promising, and we expect to see them confirmed by the ongoing post-mission data analysis. A positive outcome will confirm that it is technically feasible to extend the EGNOS service beyond the core ECAC region. It will also mean that EGNOS can potentially deliver a precision approach capability (APV-II) to the entire Mediterranean region and parts of Africa.



MIDAN RIMS

To The Emergency Room With EGNOS: *(continued from front cover)*

to hospital; and transportation between hospitals. Despite the fact that most of their helicopters are fitted with digital auto-pilots and are Instrument Flight Rules (IFR) certified, nearly all HEMS operations are carried out under Visual Flight Rules (VFR) even in adverse weather conditions. This is due to the lack of helicopter-specific IFR procedures and the lack of a landing system suitable for helicopter instrument approaches.

You may be wondering why HEMS is not already a significant user of GPS technology and pressing for the introduction of EGNOS. After all, we can draw on solid evidence from the US to support the fact that important safety and economic benefits can be gained from the introduction of IFR procedures. The statistics are compelling: a $500k US investment in IFR has returned $709k US over 24 months; and more than 2000 critically ill patients have been transported to hospital using IFR GPS approaches when weather conditions would have otherwise grounded the flights.

Having heard about the barriers for the introduction of IFR approaches, let's now discuss solutions for the helicopter landing system. We can state a basic set of requirements: any helicopter landing system must support steep glide slopes and multiple legs, and need little or no ground infrastructure.

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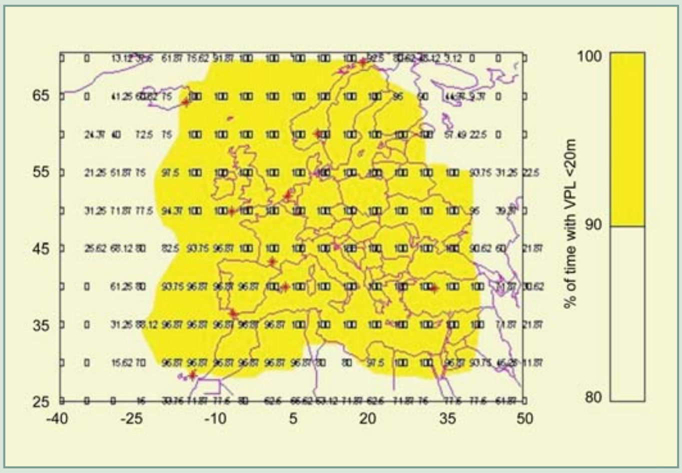
Behind the Scenes: ESTB Extends ESTB to Cover the Mediterranean

One of ESA's great achievements during the last few months has been to extend the ESTB coverage over the entire Mediterranean region and to broadcast signals from both the Inmarsat AOR-E and IOR satellites.

The first step was to connect the ESTB to the Italian Mediterranean Test-Bed (MTB), and these systems now talk to each other. This has added an extra navigation land earth station (NLES) at Fucino and two RIMS at Fucino and Matera. Most importantly, it has allowed EGNOS signals to be broadcast from the IOR satellite since mid-September.

In September, three transportable RIMS were deployed by ENAV in Egypt, Saudi Arabia and Bahrain to support the MIDAN project. Early results give us confidence that we can provide an EGNOS service in an expansion area. This will be further tested at Dakar, Senegal, in February 2003, and there will be an associated GNSS Workshop in Yaoundé. We have also been fine-tuning the algorithms and improving the software to improve the accuracy and the robustness of the signal.

You can see the results of these upgrades in the EGNOS availability figure. The ESTB can now deliver a precision approach capability (APV-II) over the entire EGNOS coverage area. Here at the ESTB Operations Centre in Toulouse, the APV-II service has been available 95% of the time between September and November.



ESTB- APV-II Vertical Protection Limit Availability

SBAS Interoperability Explained: Delivering A Global Service: *(continued from front cover)*

What other SBAS's are there?

In the mid-1990s, three regions took up the gauntlet to develop SBAS systems: Europe, the US, and Japan.

We have already written extensively about EGNOS in previous issues and so interested readers should visit the ESTB News archive on the ESA web site.

In the United States of America, the Federal Aviation Administration has taken the lead for developing its Wide Area Augmentation System or WAAS. The WAAS signal was made available for non-aviation users in 2000. It currently delivers accuracies of one meter horizontal and two meters vertical and supports aviation precision approach (APV-1) performance. An Initial Operational Capability (IOC) for aviation use is planned for June 2003 and its Full Operational Capability (FOC) is planned for the end of 2007.

Japan is developing an SBAS founded on its Multi-function Transport Satellite (MTSAT) called the MTSAT Satellite Augmentation System or MSAS. The first phase based on single geostationary satellite coverage is planned for 2004, while the second phase based on dual geostationary satellite coverage is planned for 2005/6. We expect MSAS to deliver a Non Precision Approach capability, and this could be enhanced to provide precision approach performances (e.g. APV-1).

Other regions are also interested in providing SBAS services although their plans are less advanced than Europe, the US and Japan.

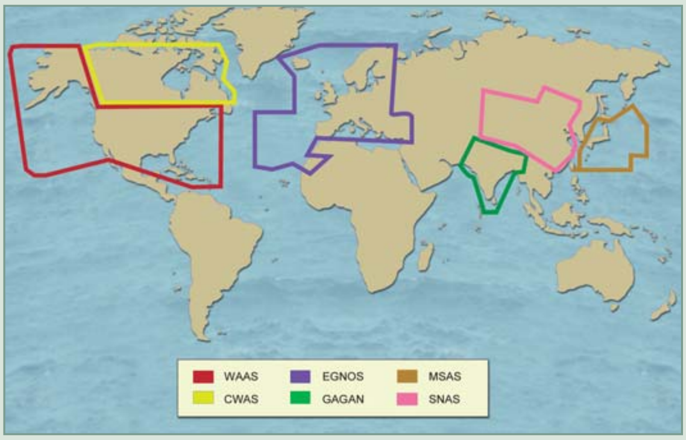
NAV Canada's SBAS (known as CWAAS) strategy is based on an extension of the US WAAS coverage by deploying a network of reference stations and linking these to the US WAAS master control stations.

India's SBAS, GAGAN (GPS and GEO Augmented Navigation), is being co-ordinated by the Indian Space Research Organisation and the Airports Authority of India. They are planning for an initial operational capability in 2006/7.

The People's Republic of China is deploying its Satellite Navigation Augmentation System (SNAS). There is also a high level of interest in Brazil and the African continent.

EGNOS	European Geostationary Navigation Overlay Service
WAAS	US Wide Area Augmentation System
MSAS	Japanese MTSAT Satellite Augmentation System
CWAAS	Canadian WAAS
SNAS	Chinese Satellite Navigation Augmentation System

SBAS Definitions



Systems Service Volumes (Illustrative)

How will SBAS services evolve over time?

Let's start by stressing that there is a future for SBAS services even after GPS has been modernised and Galileo has become operational. SBAS will still be an important source of differential corrections, and their integrity information will still be crucial for safety-of-life users.

Perhaps the first thing to discuss is when the different SBAS services will become available. SBAS services for safety-related users in the US, Europe and Japan should be available by 2004/5. We should soon hear which other regions or countries are going to provide SBAS services, and these will probably be introduced in the 2008-2015 timeframe.

Future SBAS system upgrades really depend on GPS and GEO modernisation and the introduction of new Galileo services.

Looking at the GPS modernisation plans, we will have a second civil signal at the L2 frequency (1227.6 MHz) (first launched planned 2003/4 and IOC in 2009). This will be followed by a third civil signal at a new L5 frequency (1176.42 MHz) (first launch planned 2005/6 and IOC in 2012). Galileo services are planned to be available from 2008. New GEO satellites with a dual frequency L1/L5 capability are going to be available as early as 2004.

We could see SBAS upgraded as soon as 2007 to benefit from the GEO L1/L5 signals, 2008/9 for the GPS L2 and Galileo signals, and 2010-12 for the GPS L5 signals. These will enhance the system accuracy and availability, and users with dual frequency receivers may have some form of extended coverage. The upgrades will be backwards compatible so if you buy an SBAS receiver today, it will still work once the systems have been upgraded. Looking to the future, joint GPS/SBAS/GALILEO receivers will offer aviation users a unique and exciting opportunity to achieve GNSS "sole means" navigation.

We will also see SBASs expanded to cover the inhabited regions of the world.

The SBAS Interoperability Working Group

The SBAS interoperability has always been a pre-requisite for delivering a global seamless safety-of-life service. This was recognised early on by SBAS developers and air traffic services providers, and they have worked closely together to co-ordinate their activities at ICAO and in the Interoperability Working Group (IWG). One of their key activities has been to assist ICAO and RTCA in the development of standards: Standards and Recommended Practices (SARPS) for system developers; and Minimum Operational Performance Standards (MOPS) for receiver manufacturers. The IWG has also been a useful forum for learning lessons that have an impact on safety and programme schedule.

So what does interoperability do for me?

First of all, there are many SBAS receivers on the market, but if you buy a receiver that is compliant with the latest version of the GPS/WAAS MOPS (DO-229C), then you can be confident that your receiver will work with any SBAS signal. So, a receiver that is WAAS-compatible and compliant with DO-229C is also EGNOS-compatible.

Secondly, if you are in the EGNOS coverage area, then your receiver will be able to track the GPS look-alike signals from other SBAS satellites (e.g. WAAS). Range measurements from the WAAS satellite are valid provided that the satellite is monitored by EGNOS. However, it is important to recognise that each SBAS optimises the WAD corrections and integrity data for its own coverage area, and hence only EGNOS WAD corrections and integrity information will be valid in the EGNOS coverage area.

Finally, your SBAS receiver will also work normally outside Europe. If you are in SBAS coverage, your receiver will track both GPS and GEO satellites and deliver the service provided by the operator. Otherwise, your receiver should functional normally in a GPS-only mode.

To The Emergency Room With EGNOS: *(continued from page 2)*

We can rule out the conventional Instrument Landing system for a number of reasons, leaving GNSS-based systems. There are currently three candidates: GPS, EGNOS and ground-based augmentation systems (GBAS). Of these, EGNOS is the most appropriate because it delivers a high level of performance and needs no local ground installation.

A joint French/German team is currently validating the use of EGNOS on HEMS helicopters as part of a research programme to improve the ability of helicopters to fly in adverse meteorological conditions. They have fitted an EGNOS Test Bed User Equipment (TBUE) receiver on an EC 155-HTT helicopter. This has been coupled to the flight management system so that EGNOS-guided helicopter approaches can be flown. We look forward to reporting detailed results from this trial in a future issue.

EGNOS can deliver real benefits to the HEMS helicopters by bringing helicopter IFR approaches to reality. There will be less noise at ground level, and it should be safer to fly in adverse weather conditions. Crucially, a more reliable service with fewer cancelled flights means more lives saved.

Frequently Asked Questions

Q1. Are the WAAS signals valid in the EGNOS coverage area?

A1: Like EGNOS, the WAAS GEO satellites transmit WAD corrections and integrity data modulated on a GPS look-alike signal.

Let's start by considering the WAD corrections and integrity data. Each SBAS optimises its WAD corrections and integrity information for its own coverage area, and so users in Europe should only use WAD corrections and integrity data broadcast by the EGNOS satellites. A user in Europe will find that the WAAS data are incomplete, containing neither a complete set of corrections for all satellites in view nor an ionospheric grid model for Europe.

Moving on to the ranges from the WAAS geostationary satellites: broadly speaking, these are valid for all applications provided that they are monitored by EGNOS. In short, to have the SBAS benefits across Europe, you need to use the EGNOS system.

Q2. Why does the ESTB sometimes not improve the accuracy of GPS?

A2: There will be 34 Reference and Integrity Monitoring Stations (RIMS) in the operational EGNOS system. These will ensure that each GPS and GEO satellite in view of the EGNOS service area (ECAC) is monitored by EGNOS, and that ionospheric information is provided for all the ionospheric grid points in view of ECAC. However, in the pre-operational ESTB, only twelve RIMS monitor the same ECAC service area. Consequently, there are occasions when some of the GPS satellites in view are not declared as "monitored" by the ESTB. When this occurs, those receivers that only use WAD-corrected satellites in their position solution (i.e. they do not use GPS that are not monitored by the ESTB) may experience a degradation of geometry and a corresponding loss of accuracy. Again, this should not be an issue at all once EGNOS is fully operational, because all GPS satellites in view will be monitored and hence the EGNOS solution will always improve the accuracy of GPS.

Forthcoming Events

Munich Satellite Navigation Summit,
24 – 26 March 2003, Munich, Germany

GNSS 2003, Graz, Austria,
22 - 25 April 2003, www.gnss2003.com.

World Radiocommunication Conference.
9 June to 4 July, 2003, Geneva. Switzerland. www.itu.int

ION 59th Annual Meeting.
23 –25 June 2003, Albuquerque, NM, US. www.ion.org

IUGG2003.
30 June – 11 July 2003. Sapporo, Japan. www.iugg.org

ION GPS-2003.
9 - 12 September 2003, Portland, OR, US. www.ion.org

IAIN World Congress 2003.
21 – 24 October 2003. Berlin. Germany. www.dgon.de

Links and Contacts

ESA Navigation Web Page:
http://www.esa.int/navigation

ESA EGNOS Web Page:
http://www.esa.int/EGNOS/

ESA ESTB Web Page:
http://www.esa.int/ESTB

ESA SISNET Web Page:
http://www.esa.int/SISNET

ESA ESTB Help Desk:
ESTB@esa.int

ESTB News:
ESTB-News@esa.int

SISNET Administrator:
SISNET@esa.int

ESA Galileo Web Page:
http://www.esa.int/Galileo

ESA Artemis Web Page:
http://www.esa.int/artemislaunch/

EC Galileo Web Page:
http://europa.eu.int/comm/dgs/energy_transport/galileo/index_en.htm

FAA GPS Product Team:
http://gps.faa.gov/

USCG Navigation Center GPS Page:
http://www.navcen.uscg.mil/gps/

Help Us to Help You

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