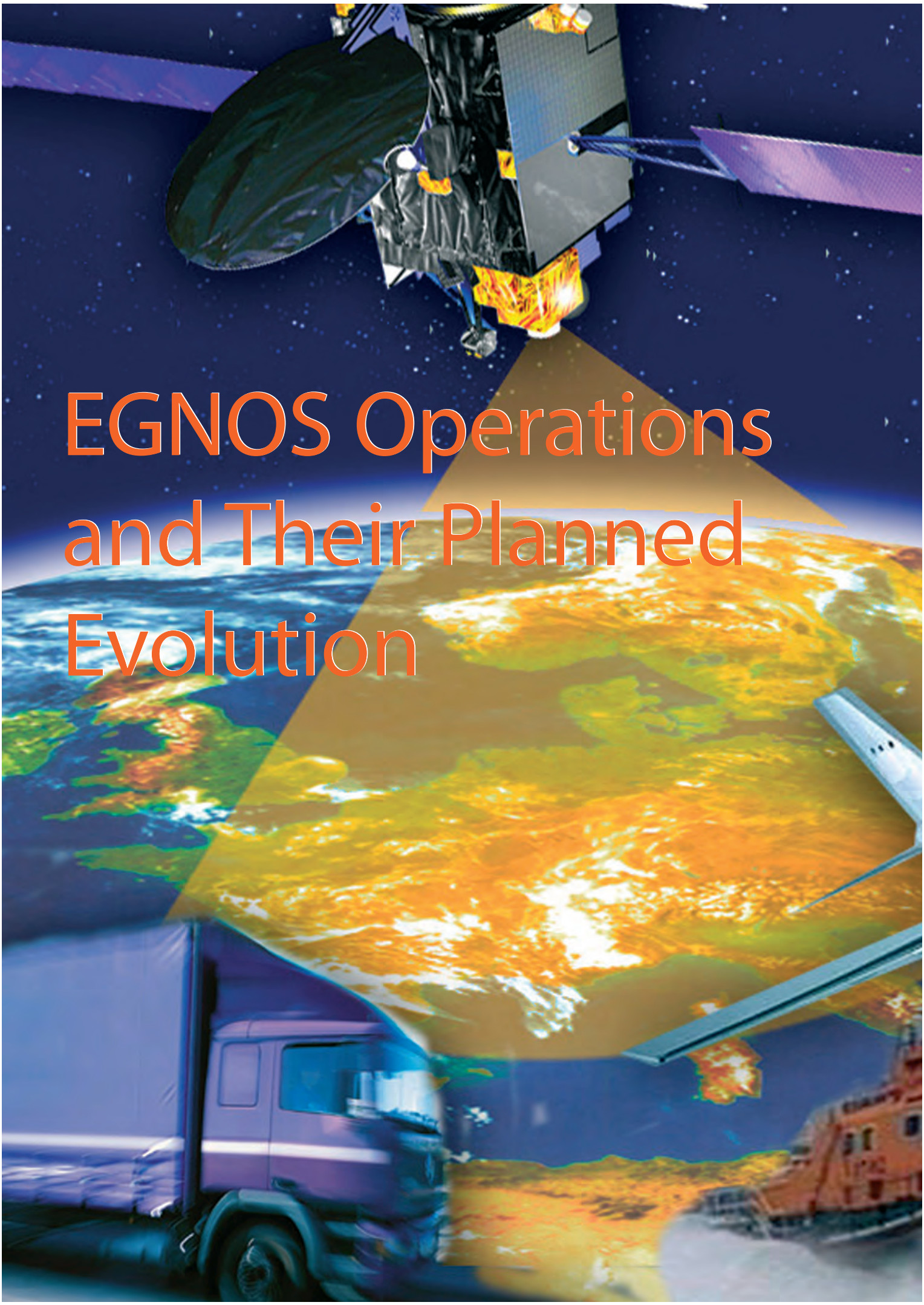
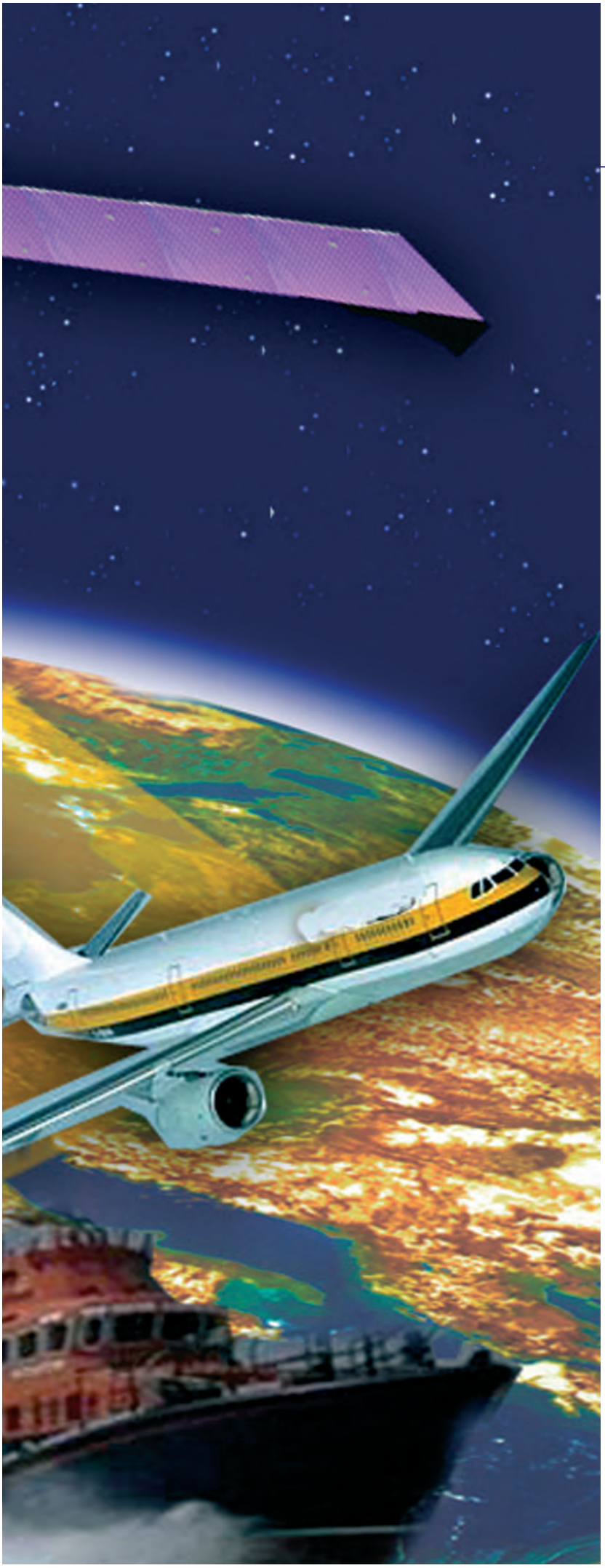


EGNOS Operations and Their Planned Evolution



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This summer, after more than 8 years of intensive work by ESA and European Industry, the European Geostationary Overlay Service (EGNOS) achieved two major programme milestones, with the successful completion of the formal technical-qualification process (Operational Readiness Review) and the start of initial operations. The measured performance of the system has already been shown to exceed requirements in several respects.

Via the EGNOS project, the European Tripartite Group – constituted by ESA, the European Commission and Eurocontrol – has implemented the European contribution to the first-generation Global Navigation Satellite System (GNSS-1). ESA has been responsible for the system design, development and qualification of the advanced operational system, also known as EGNOS V1.

In parallel with the start of operations, the EGNOS system will now be enhanced to enlarge the service area, to provide additional services, to further improve performance and to follow the global evolution in Satellite-Based Augmentation Systems (SBAS) that is taking place, leading up to the introduction of the European Galileo system.

Today's Situation

The EGNOS ground infrastructure currently consists of four Mission Control Centres (MCC), six Navigation Land Earth Stations (NLES), and thirty-one Reference stations (called RIMS). Since December 2003, when the first transmissions were made, three geostationary satellites – Inmarsat-3 AOR-E, Inmarsat-3 IND-W and ESA''s Artemis – have been successfully transmitting EGNOS signals. To complete the formal qualification process of the EGNOS V1 development programme, an Operational Readiness Review (ORR) was held in May/June 2005 involving more than 60 peers, including ESA, Civil Aviation, Galileo Joint Undertaking and Eurocontrol reviewers. Meeting on 16 June, the Board concluded that:

- EGNOS technical qualification was successful, subject to the completion of some review actions and recommendations.
- EGNOS Advanced Operational Capability (AOC) requirements were verified and are largely met.
- The system was ready to enter the Initial Operations Phase as EGNOS V1.

The Initial Operations, managed by ESA, have therefore started in July 2005, following the successful conclusion of negotiations between ESA and the ESSP (European Satellite Services Provider). The main objectives are to ramp-up and stabilise the technical operation of the EGNOS Ground Segment and Support Facilities, then to conduct an Operations Qualification Review (OQR) in order to arrive at an operationally qualified system able to support safety-of-life services (e.g. aviation). Each phase (ramp-up, stabilisation and qualification) is planned to last six months, with the OQR planned to take place by end-2006. Thereafter EGNOS system operations will be directly controlled by the Galileo Concessionaire.

System Performance

The performance review panel that conducted the ORR concluded that all EGNOS system performance targets, extrapolated to operational conditions, are fully met in terms of accuracy, integrity and availability. As an example, the accompanying figure shows the horizontal and vertical navigation-error accuracies as measured at nine different European cities during the performance-qualification phase. Being in the order of 1 m and 1 to 2 m, respectively, they are much better than the specified requirement of 7.7 m.

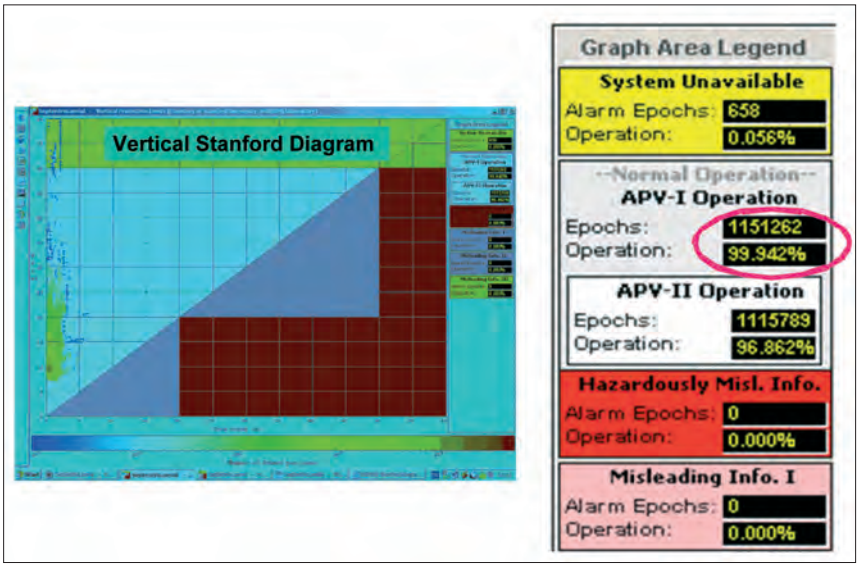
Place	Paris	Toulouse	Madrid	Brussels	Geneva	Palma de Mallorda	Lisbon	Cork	Berlin
HNSE (95%)	1.0	1.0	1.1	0.8	0.9	1.1	1.1	1.3	1.1
VNSE (95%)	1.3	1.6	1.4	1.6	1.5	1.5	1.7	1.9	1.6

The horizontal and vertical positioning performance of EGNOS

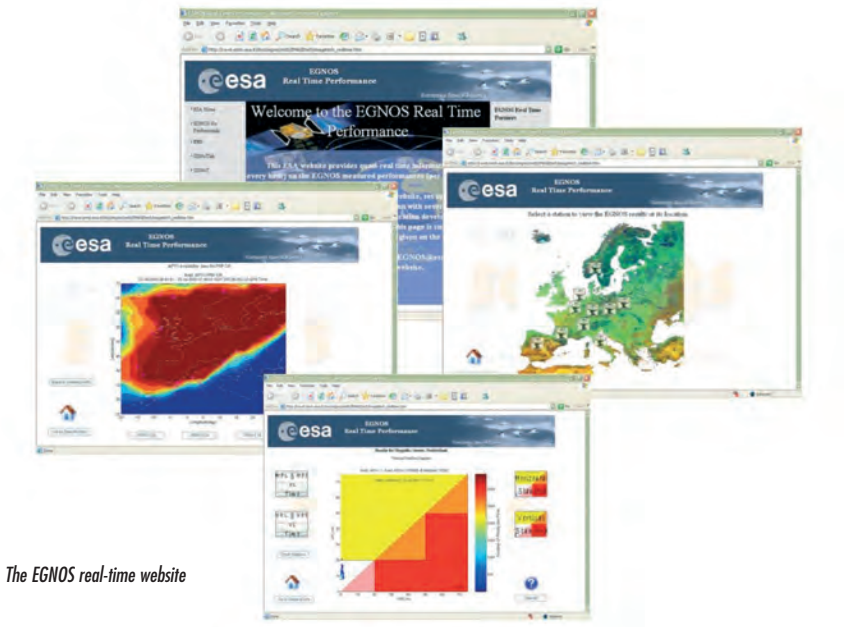
The second figure shows the cumulative availability of the system as measured at the Project Office facilities in Toulouse in February 2005 during the qualification campaign. The measured availabilities were 99.94% for APV-1 and more than 95% for APV-2, thereby exceeding the formal requirements of 99% and 95%, respectively.

The Integrity of EGNOS V1 was also assessed during the qualification campaign by both ESA (through the IMAGE Project) and Industry. With over 20 000 0000 samples analysed, it confirmed that not a single 'misleading information' event was observed at any location in Europe and that comfortable safety margins exist. Even during the severe solar storm that occurred in October 2003, which was one of the largest ever recorded, EGNOS would have provided a totally reliable service at all of the 17 locations checked with full vertical-guidance capability (APV) and with no 'misleading information events' at user level. Knowing that the US WAAS system had to interrupt its service during this storm, this is an extremely encouraging result that further boosts confidence in the safety of EGNOS.

To promulgate such information on EGNOS's performance, and to support



The EGNOS availability figures (APVs) measured at ESA in Toulouse



The EGNOS real-time website

application development, ESA has created a dedicated website (at http://www.esa.int/navigation/egnos-pro) where the performance data are updated hourly for several European cities.

EGNOS Evolution 2006-2010

The Context

The original EGNOS mission requirements were defined in 1998, but since then the Global Navigation Satellite System (GNSS) environment has expanded considerably, with the launch of the Galileo Programme and the planned modernisation of the Global Positioning System (GPS), with for example the introduction of the GLPS L5 civil frequency and WAAS systems. In this global context, the Council of the European Union confirmed in June 2003 that:

– EGNOS is an integral part of the European Satellite Navigation Policy
– EGNOS should be adapted as needed to follow the SBAS International Civil Aviation Organisation (ICAO) international-standard upgrades, and
– EGNOS services should be resolutely extended to other parts of the World on a long-term basis.

In addition, several studies indicate that modernised SBAS systems in combination with the European Galileo services, could lead to GNSS being the 'preferred solution' for even the most demanding life-protecting safety applications.

In response, a GNSS Support Programme has been defined by ESA and the European Commission. It is designed to further maximise the benefits of GNSS for Europe's citizens, and in particular to define and implement the most appropriate EGNOS developments, paving the way for the expected boom in Galileo services from 2010 onwards. It is being implemented in two steps: Step 1, covering 2005-2006, and Step 2 the 2006-2010 time frame.

The drivers behind the planned EGNOS evolution are essentially:

– its extension beyond the European (ECAC) service area
– the follow-up of International Standards, so that EGNOS always remains interoperable with WAAS and MSAS
– targeting of 'sole-means' status for EGNOS safety-of-life applications when combined with Galileo
– fostering Galileo multimodal service penetration
– maintaining European Industry excellence in GNSS/SBAS technologies.

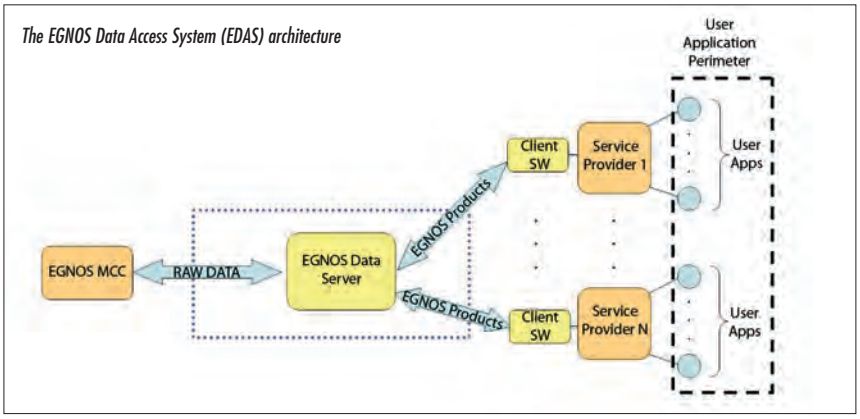
The Infrastructure

In June 2005, ESA launched an EGNOS Evolution definition phase to establish a viable plan for infrastructure development plan so that the EGNOS mission-evolution concepts identified as desirable can be successfully implemented in the 2006-2010 time frame (see figure). These concepts currently include:

STEP 1 — STEP 2: EGNOS Evolution Programme

EGNOS V2.1 in 2006	EGNOS V2.2 in 2007/8	EGNOS V2.3 in 2008/9	EGNOS V3 in 2010/11
EGNOS Data Server Extension to MEDA Region Critical technologies assessment Consolidation of EGNOS Infrastructure Evolution Plan	Regional Extension Module (REM) concept Extension in Africa ESA ALIVE concept	L5 Message standards and initial L5 GEO broadcast GPSL1/L5/Galileo /Glonass enhanced RIMS receivers	MRS Concept (Multi-constellation Regional System) • GPS L5 augmentation Service • Galileo Augmentation (TBC) • Glonass modernisation augmentation (TBC)

Proposed EGNOS Infrastructure Evolution plan



The EGNOS Data Access System (EDAS) architecture

– The EGNOS Data Access System (EDAS: EGNOS V2.1).
– The Regional Extension Module (REM: EGNOS V2.2).
– The ESA Alert Interface via EGNOS (ALIVE: EGNOS V2.2).
– The Multi-constellation Regional System (MRS: EGNOS V3).

EDAS

The EGNOS Data Access System (EDAS) will provide a controlled on-line interface to multimodal Service Providers, to provide real-time EGNOS products within guaranteed delay, security, and safety performance boundaries. Application Service Providers will exploit these EGNOS products to provide added-value services to end-users though broadcast means other than geostationary satellites.

The EDAS Data Server will perform the following primary functions via the INSPIRE interface:

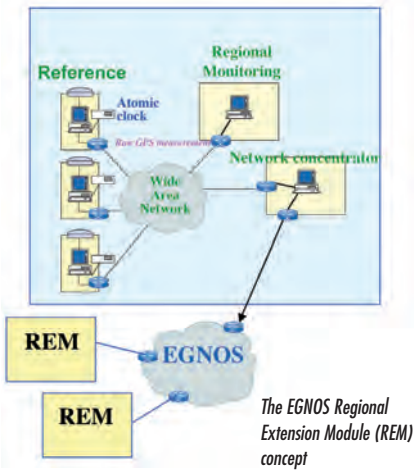
– Provide the necessary security mechanisms to protect the INSPIRE interface and the EGNOS system from external interference.
– Transform the EGNOS raw products to internationally accepted open standards.
– Allow the connection of an almost unlimited number of users.
– Allow the definition of different levels of data provision (from raw data to more elaborate products).

A large assortment of navigation-based added-value services can be based on such EGNOS Data Server products.

EDAS will be developed, in cooperation with the Galileo Joint Undertaking, via the GNSS Support Programme Step 1 with a view to having an operational server in place before end-2006, to enable its commercial exploitation by the Galileo Concessionaire. As shown in the accompanying figure, EDAS obtains the EGNOS raw data from one of the EGNOS Mission Control Centres (MCC) in real time. The Data Server then performs two main operations on the raw data:

- it converts it into EGNOS products, which are provided following internationally accepted open standards
- it provides a robust security layer, protecting EGNOS from external attack.

The EGNOS products are then made available to the Service Providers using client-specific software (to be provided by ESA). These Service Providers then exploit the EGNOS products for their added-value services, which are supplied to the end-users by means other than geostationary satellites.



The EGNOS Regional Extension Module (REM) concept

REM

One of the clear paths for EGNOS Evolution is the extension of coverage beyond the original European ECAC area. There are several possible extension target areas, including North Africa (MEDA region), the Middle East, Eastern Europe, or even the whole of the African continent. Given the large number of possible extension scenarios, and to avoid costly dedicated, a la carte solutions, ESA and EGNOS Industry have developed a generic extension concept (see figure) known as the EGNOS Regional Extension Module (REM). It consists of a number of dedicated reference stations, a local monitoring centre, a network concentrator and a clean and unique interface with EGNOS core system.

Two major benefits expected from this generic concept are:

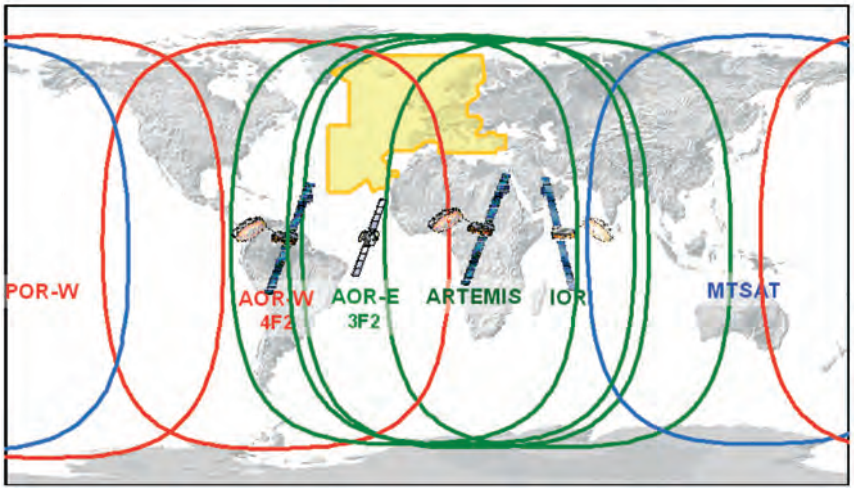
– Future EGNOS coverage extensions will be based largely on a recurrent extension design concept.
– Extension is performed in multiple steps, through the connection of several REM units, allowing controlled system scalability.

For example, only 3 to 4 REM modules are currently envisaged for providing full service coverage for the whole of Africa.

ALIVE

Disaster prevention and mitigation is a topic that is currently receiving a great deal of attention. One of the main goals is to identify ways to inform people at risk from, for instance, natural events such as earthquakes, tsunamis, hurricanes, storm surges, extreme precipitation and flooding, or volcanic eruptions, so that specific actions can be taken to mitigate the impact of the disaster and ultimately save lives. The same information channels would be valuable tools for supporting rescue and aid operations in the aftermath of disasters, thereby also reducing loss of life.

Those most affected by such disasters are often the poor and the socially disadvantaged in developing countries, who are the least equipped to cope. In countries like Africa and the Indian Ocean states, for instance, lack of communication is a severe limitation for efficient warning

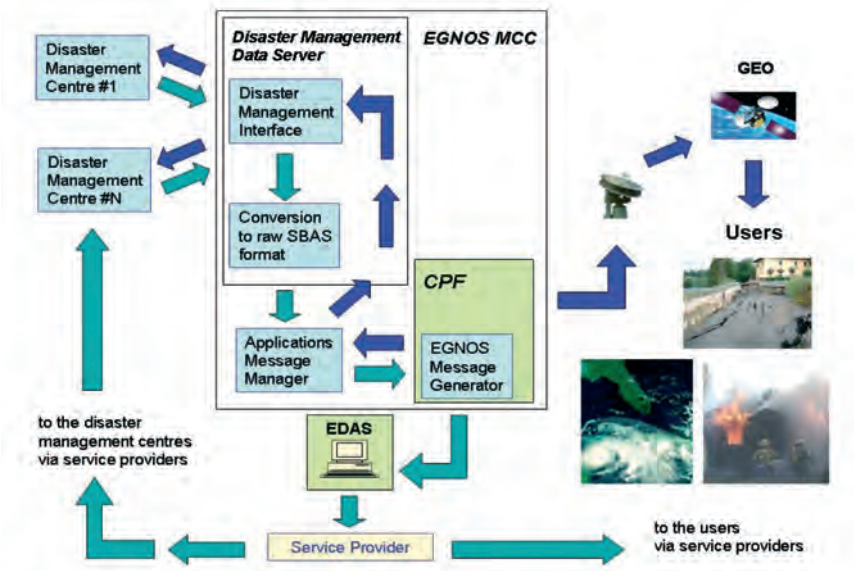


The broadcasting areas of the three existing operational SBAS systems: EGNOS / WAAS / MSAS

systems, and additional means of communication paired with a positioning service could be of great help. Using the message broadcast capacity of Satellite-Based Augmentation Systems (SBAS), i.e. EGNOS for the case of Europe, is of considerable interest, not least because:

– The three existing SBASs together provide global coverage (see figure).
– All navigation receivers are becoming SBAS-compatible and share the same worldwide accepted standards.
– It combines the possibility of warning with the ability to determine the location of the user via the same equipment (key feature).
– SBAS systems have been conceived for the 'safety-of-life' environment and are institutionally controlled and thus include the built-in design and operating features needed to guarantee integrity of message broadcasts and acknowledgments.

ALIVE is based on the more general concept of using the available spare EGNOS message broadcasting capacity for transmitting low-rate, spatially related information from an originator to EGNOS users through dedicated SBAS messages. National and international organisations responsible for disaster management or the provision of civil-protection services already make use of special infrastructures for monitoring, communication and control. These infrastructures are indicated as 'Disaster Management Centres' in the possible architectural implementation of the ALIVE concept within the EGNOS system (see figure). These Centres then have the task of collecting/generating critical information (e.g. event, location, status, action), interfacing with the EGNOS system to provide the required broadcast conformation and receive an acknowledgement that the information has been sent. All users within the EGNOS satellites footprint equipped with an EGNOS receiver capable of processing these additional messages are then made aware of the nature of the problem, its location, the current status and the actions being taken.



Architecture for the implementation of the ALIVE function

Conclusion

As the first-generation European GNSS System, EGNOS represents the first step towards Galileo, the second-generation operational system based on an independent European satellite constellation. The start of the Initial Operations phase in July 2005 marked the successful completion of more than 8 years of intense work by ESA and European Industry.

The evolutionary versions of EGNOS that will result from the EGNOS V2 and EGNOS V3 'modernisation' initiatives will enlarge the service area covered, provide additional services, and further improve system performance. Step-1 of this modernisation plan (2005-2006) has been approved and is already underway. The EGNOS Evolution Definition studies that are proceeding in parallel will produce a concrete EGNOS infrastructure Evolution Plan for 2006-2010 for ESA and EU members' endorsement.

Acknowledgement

The EGNOS Project Office would like to acknowledge the excellence of the work conducted by the European Industry staff involved in the EGNOS development effort over the last 8 years.