MEMO/11/26

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The Mid-term Review of the European Satellite Radio Navigation Programmes Galileo and EGNOS: Questions and Answers

See also IP/11/42

For the full text of the Communication on the mid-term review of the European Satellite Radio Navigation Programmes, please see:

http://ec.europa.eu/enterprise/policies/satnav

What is satellite navigation?

Satellite navigation is based on the principle of triangulation: If I know my distance from three different points, I can calculate my exact position. The Galileo Global Navigation Satellite System (GNSS) is built on the same basic principle. Four satellites in view are necessary to determine your exact position on or above the Earth – however the more satellites in view/used to calculate your position, the greater the accuracy will be.

Determining precise location depends on measuring accurately the distances between receiver and satellite, and that depends on very accurate measurement of signal travel time. As signals travel at the speed of light, travel times are tiny fractions of a second. Your receiver determines your distance from each of the satellites by measuring the time taken for the signal to travel from the satellite to your receiver antenna (the signal travels at the speed of light). For this you need extremely accurate timing, hence the reason for the extremely precise atomic clocks in the Galileo constellation. The receiver measures travel times by comparing 'time marks' imprinted on the satellite signals with the time recorded on the receiver's clock. The time marks are controlled by a highly accurate atomic clock on board each satellite which provides the time marks for your receiver to compare and calculate.

Of course, it is only possible to determine a location on Earth if you know the location of the navigational satellites very precisely. This is achieved by placing the satellites in highly stable Medium Earth Orbits (MEOs) at an altitude of about 20 000 km. MEOs are the orbits of choice for a number of reasons: their stability enables exact orbit predictions; the satellites travel relatively slowly and so can be observed over several hours, like a fixed star; and, the satellites can be arranged in a constellation so that at least four are visible from any point on the Earth's surface at any time.

What is Galileo?

The Galileo program is Europe's initiative for a state-of-the-art global satellite navigation system, providing a highly accurate, guaranteed global positioning service under civilian control. Discussions on a European system started in the late nineties and in 1999 the Council called on the Commission to develop a global system managed by public civil authorities.[1] After the failure of negotiations on a public-private partnership, the Parliament and the Council in 2008 decided to complete the constellation using EU budget.[2]

While providing autonomous navigation and positioning services, the system established under the Galileo program will at the same time be interoperable with GPS and GLONASS, the two other global satellite navigation systems. The fully deployed system will consist of 30 satellites and the associated ground infrastructure.

Based on the award of the contracts for the first order of satellites, the launch services, the system support services and the operations, the European Commission announced that three initial services will be provided from 2014 onwards: an initial Open Service, an initial Public Regulated Service and an initial Search and Rescue Service. The Safety-of-Life Service and the Commercial Service will be tested as of 2014 and will be provided as the system reaches full operational capability with the 30 satellites.

Why has the EU launched a satellite navigation programme?

Europe needs Galileo to be independent in a sector that has become critical for its economy and for the well-being of its citizens. The positioning and the timing signals provided by satellite navigation systems are used in many areas of the economy, including power grid synchronization, electronic trading and mobile phone networks. Thus, it is estimated that already 6-7% of Europe's GDP, or €800 billion, relies on satellite navigation applications.

Satellite navigation applications are also becoming ubiquitous in our daily lives and in that of police and emergency services.

Galileo is the only global navigation satellite system specifically designed for civil purposes, i.e. it aims to satisfy the requirements of the civil industry and to answer the needs of the civil sector and its performance will not be deteriorated for defence purposes.

[1] Council Resolution of 19 July 1999 on the involvement of Europe in a new generation of satellite navigation services - Galileo-Definition phase, OJ C221 of 3.8.1999.
[2] Regulation (EC) No 683/2008 of 9 July 2008 on the further implementation of the European satellite navigation programmes EGNOS and Galileo, OJ L196 of 24.7.2008.

Even before the full constellation is deployed, Galileo will provide benefits in combination with the US GPS system:

- In a combined GPS-Galileo use, compared to GPS alone, the higher number of satellites available to the user will offer higher precision. From most locations, six to eight Galileo satellites will be visible, which in combination with GPS signals will allow positions to be determined up to within a few centimetres.
- The higher number of satellites will also improve the availability of the signals in high-rise cities, where buildings can obstruct signals from satellites that are low on the horizon.
- Galileo will also provide a better coverage at high latitudes than GPS, thanks to the location and inclination of the satellites. This will be particularly interesting for northern Europe.

What is EGNOS?

EGNOS is a satellite-based augmentation system that improves the accuracy of positioning information given by GPS, by correcting errors caused by atmospheric disturbance factors. EGNOS also disseminates integrity signals in real-time, providing information on the health of the GPS constellation, a vital functionality for safety-critical applications.

EGNOS was developed by the European Space Agency (ESA) under a tripartite agreement between ESA, the European Commission and the European Organisation for the Safety of Air Navigation (Eurocontrol). Since 2008, EGNOS is entirely financed from the EU budget.

What has been achieved until now by the Galileo and EGNOS Programmes?

In 2008 the European Commission was charged with the overall management of the Galileo and EGNOS Programme under a Regulation adopted by the European Parliament and Council. The Commission's first priority was to launch the procurement of space and ground segment components required to take the Galileo Programme to full operational capability. Of the six lots tendered, four were attributed in the course of 2010 and the remaining two lots will be signed in early 2011. This means there is now a concrete deployment calendar to the first system milestone, initial operational capability, which is due to be achieved in 2014. In parallel, work has continued on the first four operational satellites which are being built under European Space Agency (ESA) auspices and which are scheduled to be launched later this year and early next year.

Progress has also been made with regard to the ground segment which consists of telemetry and telecommand centres, Galileo sensor stations, navigation message uplink and a number of service-specific infrastructures. Two telemetry and telecommand centres have been inaugurated, with a further three in the process of completion. A total of nine sensor station sites are close to implementation and an additional eight sites will be deployed for initial operational capability (IOC). For the navigation message uplink five stations have been installed and a sixth station will follow. Finally, the two ground control centres in Fucino (Italy) and Oberpfaffenhofen (Germany) have also been completed.

Meanwhile, the so-called Open Service of EGNOS was launched in October 2009 and the Safety-Critical Service destined for use by the aviation community will be declared operational in the coming months. The system has proven its reliability and is rapidly being adopted in sectors beyond aviation, notably in agriculture and geodesy, with road and maritime applications also being evaluated.

A total of 34 ranging and integrity monitoring stations, six navigation land earth stations, four mission control centres and signal transponders on three geostationary satellites (Artemis, Inmarsat AOR-E and Inmarsat IOR-W) have been deployed.

What are the economic benefits of Galileo and EGNOS?

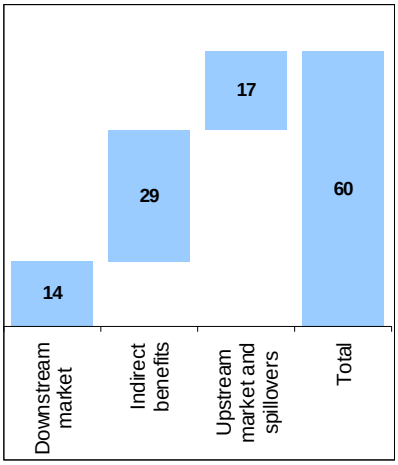
The global annual market for global navigation satellite products and services is currently valued at 124 billion Euros and is expected to grow at 11% compound annual growth rate over the next decade, leading to an estimated market size of €244 billion in 2020.[3]

Like the Internet, a global navigation satellite system is a service enabler rather than a standalone service. It acts as a catalyst for economic activities, leading to the creation of added value and jobs in a wide range of connected sectors (upstream and downstream markets) and at macroeconomic level through socio-economic benefits for society as a whole.

The expected benefits of Galileo and EGNOS can be divided into three main components:

Direct benefits resulting from the growth of the GNSS downstream[4] market:

Thanks to global navigation satellite systems (GNSS), new business opportunities are developing. Innovative uses of satellite navigation are emerging and will continue to expand in the coming years, such as road user charging or advanced driver assistance systems. Some of these applications will only become possible with Galileo through new features such as authentication. The cumulative direct benefits emanating from the GNSS downstream market are estimated to amount to €14 billion between 2010 and 2027.



Indirect benefits resulting from the emergence of new applications:

Thanks to new applications made possible by Galileo, businesses will benefit from more efficient production processes. For example, agriculture will realise increased crop productivity through more accurate seeding and spraying of fertilisers. All sectors of the economy will gain from increased speed of delivery to customers with a reduced impact of transport on the environment and greater safety.

[3] All figures are from the GNSS Market Monitoring report 2010 published by the European GNSS Agency (http://www.gsa.europa.eu/go/news/gsa-releases-gnss-market-report) except where otherwise indicated

[4] Receivers and applications

The introduction of additional GNSS – such as Galileo – will drastically increase GNSS signals availability, leading to enhanced service quality (reduction of outages, improved response time), reduced road travel time, quicker reaction time from emergency teams, all impacting our quality of life. The cumulative indirect benefits emanating from the GNSS downstream market are estimated to amount to €29 billion between 2010 and 2027.

Direct benefits resulting from the growth of the space market and technology transfer to other sectors:

Investment in the development, deployment and exploitation of Galileo supports hundreds of European companies ranging from multi-billion-euro conglomerates to specialised SMEs. Most of the funds spent on the Galileo and EGNOS programmes flow directly into the European economy.

In additional, the technological advances that come about as a result of R&D investment in the space industry are transferred to firms in other sectors in the form of 'spill-over' effects. Research by Oxford Economics[5] suggests that such spill-over effects are very large, with R&D investment by the aerospace sector generating a social return of around 70% - i.e. every €100 million invested in R&D leads to an increase in GDP of €70 million in the longer term in other sectors (e.g. health and medicine, transport, computer science). The cumulative direct benefits emanating from upstream market and spill-overs are estimated to amount to €17 billion between 2010 and 2027.

How much have the Galileo and EGNOS Programmes cost?

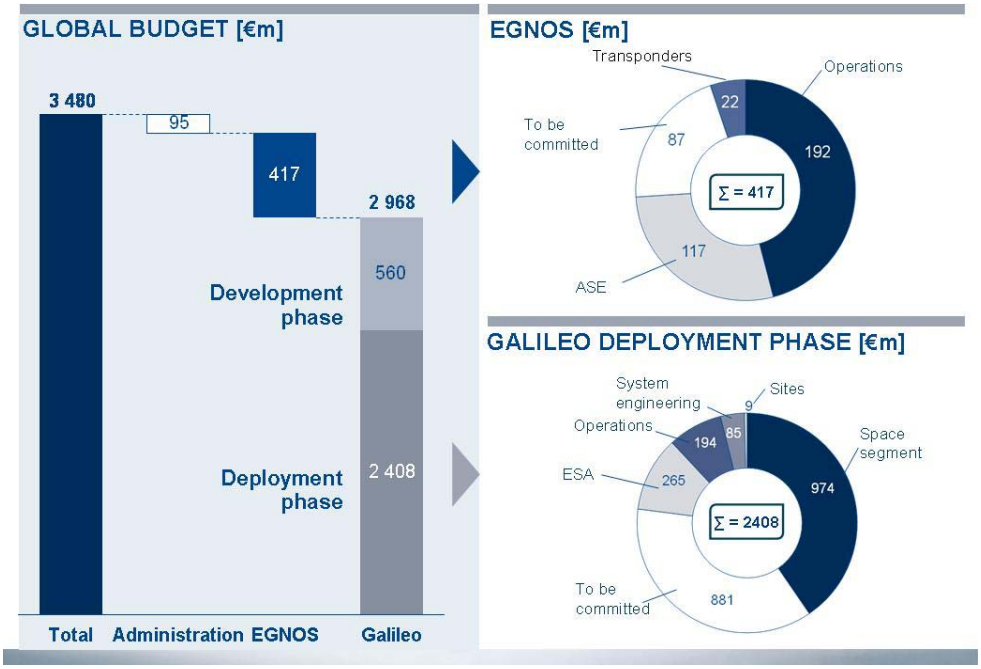
The definition phase of Galileo over the years 2000 and 2001 was financed by the EU and European Space Agency (ESA) and cost the EU contribution around €80 million (coming from the 5th Research and Development Framework Programme).

Total costs of the development phase which was launched in 2003 under the auspices of the ESA and currently on-going were initially estimated at €1100 million, equally shared between ESA and the EU. However, costs have since increased to €2100 million, with the EU providing €560 million to remedy the Programmes' budget shortfalls.

The deployment phase (so-called FOC phase) is entirely financed by the EU's budget. Of the total €3405 million made available, €560 million were required to finance cost overruns in the development and validation phase (so-called IOV phase) while around €2400 million are earmarked for the deployment phase of Galileo. €417 million have been set aside for EGNOS.

The total cost of implementing EGNOS to date has been around €1100 million. Of this, more than 400 million were financed by ESA, €200 million came from previous EU financing programmes and €417 million have been made available under the current budget framework.

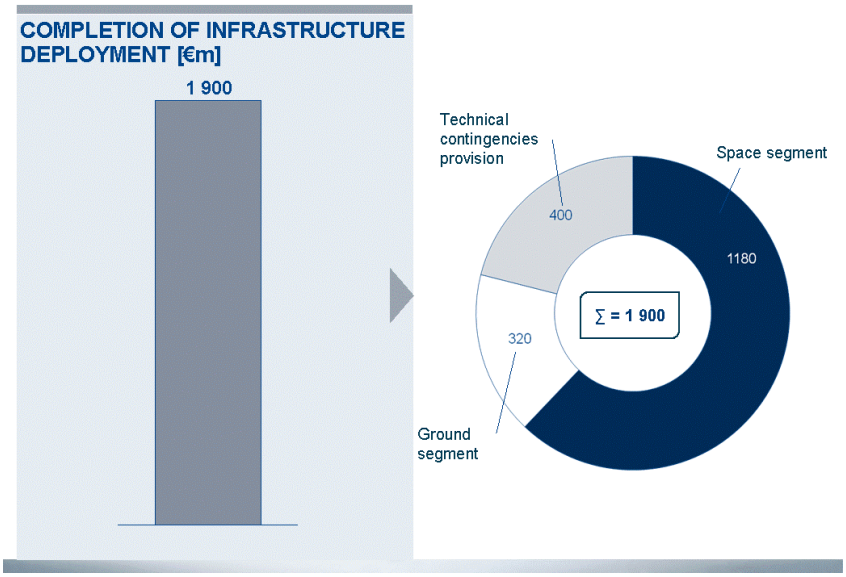
[5] The Case for Space: The Impact of Space Derived Services and Data (*July 2009)*



How much money is required to complete the two Programmes?

EGNOS is now operational and does not need additional budget for completion, over and above what is earmarked in the current budget. With the entry into operations of the Safety-of-Life service, EGNOS will enter the next phase of its life-cycle.

As regards Galileo, the completion of the constellation for the provision of the five Galileo services is estimated to require a further €1900 million, including €1180 million for the deployment of the construction and launch of the remaining satellites. These figures are indicative and without prejudice to the Commission's final decision concerning the ultimate content and structure of the Programmes. In 2011 the Commission will table a legislative proposal thereon, in the context of the preparation of the future multiannual financial framework.



Why does the Galileo budget need to be replenished?

The additional financing is required to replenish the budget assigned for the completion of Galileo. On the request of Member States, parts of this budget were used to cover financial shortfalls in the development and validation phase managed by the European Space Agency. A further factor has been the worldwide increase in launch costs, exceeding the initial estimates for the Galileo Programme. Furthermore, increasing security constraints which affect all critical infrastructures have also impacted Galileo. Finally, competition in a number of work packages has not been as strong as was initially hoped for.

When will Galileo and EGNOS be operational?

EGNOS's precision positioning service (the so-called Open Service) has been in operations over the European continent since October 2009. The next big milestone for the system is the launch of operations of the enhanced service that provides vital integrity information for safety-critical applications (the so-called Safety-of-Life service). Following certification of the EGNOS operator in the summer of 2010, launch of Safety-of-Life operations is expected in Spring of this year, opening the way for the use of EGNOS for use in aviation (precision approaches and en-route guidance).

Galileo will provide an initial Open Service, an initial Search-and-Rescue Service and an initial Public Regulated Service when a minimum of 18 operational satellites are in orbit. This milestone is planned to be achieved in 2014, depending on the production schedules of satellite and the launch rate. Galileo satellites will be launched in pairs aboard Soyuz rockets from the Kourou space port in French Guyana.

The first two satellites – built under the development phase of the Programme – are due to be launched in the third quarter of this year, with a second pair of satellites to follow early in 2012. As of end 2012, it is expected that two satellites will be launched every quarter, until the IOC (initial operational capability) constellation is achieved. The use of the Ariane-V rocket, which is capable of launching four satellites, is also being considered.

The Commercial Service and the Safety-of-Life Service will be tested once IOC is reached and will be provided as the number of satellites increases towards the full constellation. The implementation of the full constellation depends among others on the availability of further financing and is currently expected to be achieved towards the end of the decade.

How much will EGNOS and Galileo cost to operate?

The cost of operating the systems can be broken down into the costs of operating the infrastructure, maintaining or replacing the components that have a limited life-time and evolving the system in line with user requirements.

On the basis of calculations jointly elaborated with the European Space Agency, the total annual operating costs are expected to lie at €800 million, of which EGNOS will require €110 million.