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Galileo Goes Global
What to expect from Europe in establishing a navigation satellite "system-of-systems"

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Europe's standing in the international efforts in the Global Navigation Satellite Systems (GNSS) sector will have to be reconsidered in the near future. This analysis discusses Galileo's impact on the international setting vis-a-vis the other prospective providers of GNSS services and the potential users. Bilateral and multilateral efforts are recommended in order to make Galileo a real and strong global system.

Some thousand years ago navigation started with a look at the skies and the stars already helping the Chinese, Phoenicians and Vikings to orientate themselves and head towards their destination. The technology developed over time, beginning with the magnetic compass and continuing with radio direction finding. Nowadays we have made a turn back to the skies to receive information on our current position, velocity and timing. Satellites send signals down to ground stations and to the user segments telling us where we are and in which direction to go to reach our designated destination. Space-based Positioning, Navigation and Timing (PNT) applications have a wide operative range including industry and services (i.e. precision farming, mapping, public safety, surveying, telecommunication, transport, etc.), military (i.e. intelligence, target location etc.) and science (atmospheric science, environmental science, geology/geophysics, oceanography, etc.). The European Galileo system is supposed to provide these services to the benefit of users worldwide. To that purpose the responsible authorities will have to act on the global stage, representing European interests in the international efforts to establish a "system-of-systems".

GNSSs – An Overview

In 1960 the U.S. Navy was the first to successfully test a satellite navigation system (so called "Transit" system). It was as well in the United States where the first world wide ground-based radio navigation system became operational in the 1970s.[1] Thirty years ago, on 22 February 1978, the U.S. started the advancement of the system by launching their developmental navigation satellite "Space Vehicle Number 1" as an initial step towards establishing their Global Positioning System (GPS). Originating from a proposal of the Department of Defence (DoD), GPS evolved to become a dual-use system. It reached full operational capacity (FOC) in 1995. Today the U.S. is engaged in modernization efforts of the ground and space segments of GPS (GPS block III).

GLONASS (ГЛОбальная НАвигационная Спутниковая Система/Global Navigation Satellite System) is similar to GPS designed as a dual-use system. The first GLONASS satellite was launched into orbit in 1982. FOC was reached in 1995. In the following years the constellation was scaled down, due to the economic problems triggered by the end of the Soviet Union. Having received strong political backing on highest level, the current Federal Target Programme started in 2002. Up to today GLONASS is in the phase of reconstruction and development with a new generation of satellites (GLONASS-M) expected to reach FOC in 2010.[2] With that Russia aims to improve the accuracy of the signal, to concentrate on signal modernization, to improve the time reference,

[1] The Development of GPS. 26 May 2008 <http://ezinearticles.com/?The-Development-of GPS&id=352650>.

[2] International Committee on GNSS, Providers Forum. 24 June 2008<http://www.unoosa.org/oosa/en/SAP/ gnss/icg/providersorum.html>.

and to guarantee the interoperability with GPS and Galileo.

In contrary to GLONASS and GPS, the European system Galileo has been planned from the very beginning to be exclusively under civilian control. It aims at providing a highly accurate and guaranteed global positioning service. Full interoperability with GPS and to the largest extent possible with GLONASS are foreseen. The European Space Agency (ESA) and the European Union (EU) represented by the European Commission (EC) are partners in the project. While ESA is responsible for definition, development, and in-orbit validation of the space segment and the ground element the EC is in authority for the political dimension and the high-level mission requirements. By 2013 Galileo will be a fully deployed system. Even though the concept is promising and the first developmental satellite, GIOVE-A, was launched successfully in December 2005 and GIOVE-B followed most recently in April 2008, Galileo has been forced to be re-profiled both in terms of governmental and financing structures. The EC had to abandon the idea of financing the project through a public-private-partnership (PPP) with industry.[3] In September 2007, the Directorate General for Energy and Transport, which is in charge of Galileo in the EC, unveiled the plan for a 100 percent public financing of Galileo's 3.4 billion Euros deployment costs by transferring funds from agriculture, administration, and research categories in the current budget of the EU.

Summarizing the recent difficulties, it is obvious that political decisions on Galileo are somewhat harder to take than in the case of genuine national systems due to the constraints inherent to the structure and procedures of the Union. However, with the revised structure of Galileo there is hope that Europe will succeed and re-establish the credibility for the project both in Europe and on the international stage.

An agreement in 2003 committed China to investing about 200 million Euros in the cooperative development of the Galileo system (direct and in-kind contributions). The contributions for the in-orbit-validation (IOV) phase have already been made, while a support for the fully-operational-capability (FOC) depends on future decisions on both sides. However, in October 2006 China announced that it would build a full-fledged GNSS system.[4] Already in April 2007, China launched a PNT satellite and began broadcasting signals. A regional service (called Beidou) should be provided by 2009. The so-called Compass system will consist of an open service and an "authorized" positioning, velocity and timing communications service with global reach. It could begin global operation in 2012 if the political decisions are made. By now some issues have been raised concerning Chinese aspirations to place its signal atop frequencies foreseen for Galileo's restricted service. In any case, this issue will have to be solved on bilateral basis to prevent future disputes.

Apart from these systems India and Japan are on course to develop regional systems. One of them is the Indian Radio Navigation Satellite System (IRNSS) with its first satellite to be launched by the second half of 2009; the entire constellation should be completed by 2011. Another regional system is the Japanese Quasi-Zenith Satellite System (QZSS) with the first satellite planned for launch in 2009.

In addition to the global full-scaled systems and the regional systems various augmentation systems have been established or are currently under development. Augmentation systems are designed to correct the error that is created when the satellite signal travels through the Earth's ionosphere and atmosphere. A Japanese project is the Multifunctional Transport Satellite Space-Based Augmentation System (MSAS) which will transmit corrections and integrity data for GPS. The European Geostationary Overlay Service (EGNOS) will complement GPS (and perhaps in the future also GLONASS) by reporting on the reliability and accuracy of the signals. It should be operational by the end of 2009. The Wide Area Augmentation System (WAAS) augments GPS over the North American territory. GEO Augmented Navigation System (GAGAN) is India's Space Based Augmentation System (SBAS) for the south Asian region. It should be operational by 2010. The Russian System of Differential Correction and Monitoring (SDCM) is intended to adjust information for GLONASS, GPS and GALILEO systems. The system is foreseen to be operational by 2011. In China the Sino Navigation Augmentation System (SNAS) has been operational since 2004.

[3] The decision had a complex background, including organisational (i.e. the governing structure of the consortium, problems in the transfer of risk concerning especially system design, as well as commercial revenue and market development) and political considerations. Source: Peter, Nicolas. "Space Policy: Issues and Trends in 2006/2007." ESPI Report, 6 Sept. 2007. http://www.espi.or.at/images/stories/dokumente/studies/6th%20espi%20report.pdf

[4] Gibbons, Glenn. "China GNSS 101: Compass in the Rearview Mirror." InsideGNSS, January-February 2008, 63.

With an additional payload offering navigation and positioning related services on the Nigerian Communications Satellite (NIGCOMSAT), Nigeria has stepped in as the first African country with plans to enter the GNSS field.[5]

GNSS have by their nature many elements in common. They are/will be global systems accessible by users worldwide, they are/will be broadcasting open signals free of charge and they are/or will be having comparable atomic time and geodetic coordinate frames. By guaranteeing the interoperability of the different systems, locations that now have poor coverage might no longer need augmentation. Furthermore, new applications will evolve and economic activity might increase.

Cooperation – a Global Approach for Global Systems

GNSS should be designed with the objective of being a public good to the largest extent possible. A full scale public good is non-rival and non-excludable. Applied to GNSS the theory of public goods would imply that the consumption of the services provided should not reduce the availability of services for other users and at the same time the access to the services should not be limited. In this case, the restricted commercial signal of Galileo and the military signals of the other GNSS providers do not fall under the theory as they have by their nature an exclusionary effect. However, the objective should be to provide the public with the most effective service to the largest extent possible. The central question thus is how the supply of the open signal can be secured and shaped to use the global resources effectively? In the case of GNSS the focus must be laid on how to effectively coordinate the existing systems and the systems in development to offer the best possible solution for the consumers. This is best to be reached by establishing a “system-of-systems”.

Coordination is the key for effectively deliver the best solution for all actors concerned. Still, the real challenge for GNSSs is not to enforce certain standards, but to choose them and to provide them with certain procedures. A prominent example of the application of the international standard setting is the “Coordinated Universal Time”, which evolved triggered by the necessities of a new era of a more connected world end of the 19th century. Today we face an even more interdependent world and mobility is at the heart of it. For GNSS the incentives to coordinate efforts are overwhelmingly stronger than the arguments for free-riding. This assumption is proved by the recent establishment of the International Committee on Global Navigation Satellite Systems (ICG) within the framework of the United Nations (UN).

The ICG has been formed as an informal body on a voluntary basis to promote cooperation in the field of civil satellite-based PNT and value-added services, as well as on the compatibility and interoperability of GNSSs. Based on mutual interest, the support for sustainable development, particularly in developing countries is included in the objectives of the committee. This was laid down in a meeting in December 2005 in Vienna (Austria). The United Nations Office for Outer Space Affairs (UNOOSA) was appointed to serve as the Secretariat of the ICG. Following that, the first meeting of the Committee took place in November 2006. Topics on the agenda were especially related to applications such as efficiency and safety of transport, search and rescue, land management and sustainable development. Having thus put emphasis on the general frame in which the coordination of the global efforts would be beneficiary, the next meeting in September 2007 in Bangalore (India) brought the establishment of the Providers Forum. This platform aims directly at the subject of standardization with the explicit objective to enhance compatibility and interoperability among current and future system providers. Represented are China, the European Community, India, Japan, Russia and the United States. A new qualitative level of discussion on key technical issues and operational concepts such as compatibility and interoperability of the open services, the protection of GNSS spectrum, orbital debris/orbit de-conflictions was thus enabled. The next meeting will be held in Pasadena (United States) in December 2008. The common efforts aim to lead to a “system-of-systems”.

Galileo Goes Global

Europe is fully included in the activities under the UN umbrella. It is present in the ICG, as well as in the Providers Forum. Europe is also aware of the GNSS revolution coming along with new signals, new applications, lower prices, better maps and more accuracy. For Europe maximizing its benefits makes international cooperation an imperative part of

[5] Offers some applications related to navigation and positioning, such as: Fleet Management System, Maritime and Aviation Applications, GPS Data Logging; <http://www.nigcomsat.org/Services.html>.

the programme. Keeping that in mind Europeans have to work on two levels to ensure the success of Galileo on the international stage.

Firstly, Europe has to cooperate with the countries which already operate or will soon be operating satellite navigation systems. A first link has been established by joining the ICG and the Providers Forum. Additionally, the relevant standardisation bodies have been included in the interactions, such as the International Civil Aviation Organisation (ICAO), the International Maritime Organisation (IMO) and the International Telecommunication Union (ITU). Bilateral negotiations on the other hand are the key to guarantee non-interference of the military signals of GPS, GLONASS and Compass and the Public Regulated Service (PRS) of Galileo.

Secondly, international cooperation with non-provider countries is necessary for guaranteeing the access to global markets. Europe has to invest today in what will become a growing worldwide market in the future. On one hand an early engagement will secure the economic success and on the other hand once operational Galileo will be an important asset to offer public services on a global scale.

Some initiatives have already been taken reaching for Asia, South America and the Mediterranean regions. In China the "China-Europe GNSS Technology Training and Cooperation Centre" (CENC)[6] has been established in 2003 in a joint effort from the Ministry of Science and Technology of the People's Republic of China, the EU Commission and ESA. The CENC aims to promote cooperation between China and Europe in satellite navigation. Lately, the centre experienced some difficulties with cooperation being affected. Galileo is as well promoted in the Mediterranean region. There the "Euro-Mediterranean Satellite Navigation Project" has set up training and demonstration activities for the benefit of the Mediterranean partners.[7] In Cairo (Egypt), a Galileo cooperation centre has opened its doors in 2004. In South America the "Galileo Information Centre for Latin America" has been established in Sao Jose dos Campos (Brazil) in 2005. It is hosted by the "Regional Centre for Space Science and Technology Education for Latin America and the Caribbean".[8] Within others it aims to disseminate information about EGNOS and Galileo, as well as to facilitate long-term uptake of European GNSS in the region. The Information Centre is working towards the establishment of a network of associated centres to involve other countries in the common effort.

Bilateral agreements[9] have been negotiated with the United States[10], China[11], Israel[12], Morocco[13], Ukraine[14] India[15] and South Korea[16]. Up-to-now they are still pending in non-ratified status. Some of these agreements have been jeopardised by the transition of responsibility from the Galileo Joint Undertaking (GJU) to the Galileo Supervisory Authority (GSA) on 1 January 2007. Even though the decision adopted by the Council for Transport, Telecommunications and Energy in March 2007 authorised the Commission to negotiate with non-EU countries for concluding agreements on associated memberships in the GSA[17], there is up to now no place for third countries foreseen in the genuine structure of Galileo's new leading authority. A proposed Galileo International Board (GIB) being composed of

6 China-Europe GNSS Technology Training and Cooperation Center. 31 Mar. 2008 <http://www.cenc.org.cn/en/>.

7 Euro-Med GNSS Project. 1 Apr. 2008<http://www.gsa.europa.eu/go/galileo/international-co-operation/euro-med-gnss-project>.

8 Galileo Information Centre for Latin America. 4 Apr. 2008 <http://www.gsa.europa.eu/go/galileo/international-co-operation/galileo-information-centre-for-latin-america>.

9 Galileo Overview. 29 May 2008 <http://www.unoosa.org/pdf/icg/providersforum/02/pres02.pdf>.

10 Agreement on the Promotion, Provision and Use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications. 16 June 2008. <http://pnt.gov/public/docs/2004-US-EC-agreement.pdf>.

11 Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) – Galileo between the European Community and its Member States and the Peoples Republic of China. 16 June 2008. <http://ec.europa.eu/external_relations/china/docs/galileo_agreement_06-13324.pdf>.

12 Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) between the European Community and its Member States and the State of Israel. 17 June 2008 <http://ec.europa.eu/dgs/energy_transport/galileo/documents/doc/2004_09_01_accord_eu_israel_en.pdf>.

13 Co-operation Agreement on a Civil Global Navigation Satellite System (GNSS) between the European Community and its Member States and the Kingdom of Morocco. 12 June 2008 <https://fco-stage.fco.gov.uk/resources/en/pdf/pdf19/fco_ref_cm7201_moroccognss>.

14 EU and Ukraine seal GALILEO and aviation agreement. 10 June 2008. <http://www.comspacewatch.com/news/viewpr.html?pid=17035>.

15 The GALILEO family is further expanding: EU and India seal their agreement 28 May 2008 <http://ec.europa.eu/external_relations/india/news/ip05_1105.htm>.

16 Die EU und die Republik Korea unterzeichnen GALILEO-Abkommen. 28 May 2008 <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/1170&format=HTML&aged=0&language=DE&guiLanguage=fr>.

17 Press Release 2791st Council Meeting. 20 June 2008 <http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/trans/93264.pdf>.

representatives of the Commission, the Member States and one delegate for each associated member was not followed up.[18] These problems of integration are partly related to the PRS, which will be managed by the GSA.[19] The future of international cooperation in the Galileo project was – and to a certain extent still is – marked by incertitude. India has recently been seeking participation in the restoration of the Russian GLONASS system. Additionally, the frequency issue with the Chinese will continue to be subject to intensive bilateral discussions, affecting also cooperation plans.

However, Galileo is expected to move ahead. In April 2008, the European Council and the European Parliament agreed that the financing and increasing support will be backed by new institutional arrangements. Part of this new agreement will be the setting up of a Galileo Inter-Institutional Panel (GIP) represented by three members of the European parliament, three members of the European Council for Transport, Telecommunications and Energy and one of the European Commission. Within that frame the GSA will monitor security issues and the commercialization of the system. The GIP will meet four times a year to decide on Galileo's annual programme, international relations, governance and attribution of contracts. In the document approved by the European Parliament on 23 April 2008, it is stated that "On international agreements, the Commission will inform the GIP so that it can follow closely international agreements with third countries."[20] However, the change in the funding structures and the withdrawal of the private stakeholders will provide the Commission with the strongest power to conclude new or re-negotiate already existing international agreements.

What to Expect from Europe

Summarizing, it can be stated that though the recent difficulties Europe has started to take the steps necessary for a successful implementation of Galileo as a global system. Still there are some important points to consider:

1. Although the delay of the Galileo project, Europe must stick right now to the original concept of establishing Galileo not only as a constellation with global coverage as referred to its technological capabilities, but also as a system providing the potential users with global access to Galileo's services.
2. Though building up contacts with Asia, South America and the Mediterranean regions is imperative for economic considerations, it might as well cause resentment from other providers of GNSS and thus harm the international coordination effort. A careful diplomatic approach and the concentration on regions of major interest (i.e. South America, the Middle East) are recommended.
3. Europe should position itself as a credible partner for other providers of navigation services on the international stage, especially in the frame of the ICG and the Providers Forum. From now on, the process of implementing Galileo must be stringent demonstrating Europe's capacity to successfully concentrate its capabilities and to be a credible and strong actor in the international context. The upcoming meetings of the ICG in the United States in December 2008 and in Russia in 2009 will be a chance to demonstrate European willingness for a comprehensive engagement.
4. Taking into account the recent issues with the Chinese on the frequency/signal placement for the public regulated service, it is high time to put an effort on the bilateral talks with especially China and Russia. A stable Galileo system has to secure independence in the question of restricted signals and Europe has to put a diplomatic effort to reach the bilateral agreements necessary.
5. The efforts to establish international cooperation on bilateral basis have to be re-launched. Having brought Galileo back on track by developing new structures and a new way of financing, it is high time for the Commission to set the next steps to restore credibility and to reach out for international partners. It is recommended to bring into being the Galileo International Board (GIB) as a coordination body on the level of the European GNSS Programme Committee or

[18] House of Commons: Publications and Records. 20 June 2008<http://www.publications.parliament.uk/pa/cm200607/cms elect/cmeuleg/41-xx/4119.htm>.

[19] Triggered by the difficulties mentioned, there were statements from government officials in mid-2006 estimating that Chinese and Israeli cash deposits with the GJU would likely be refunded. Source:Europeans Raise Red Flags Over Chinese Satellite Navigation Plan. 18 Apr. 2008 <http://www.space.com/spacenews/archive06/China_061206.html>.

[20] Amended proposal for a Regulation of the European Parliament and of the Council on the further implementation of the European satellite radionavigation programmes (EGNOS and Galileo). 11. June 2008 <http://register.consilium.europa.eu/pdf/en/08/st08/st08046.en08.pdf>.

to adapt the Galileo Inter-Institutional Panel (GIP) to possibly include international partners in that frame.

In any case Europe has to take into account the fact that it is of fundamental importance for the civil-controlled Galileo system that the interoperability is guaranteed with other systems and that the consumer oriented approach is followed. Europe is already part of an international effort and will have to continue its struggle to be in a good shape and position for an upcoming “system-of-systems”.

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