Australian National University

ANU Centre for European Studies Briefing Paper Series

Galileo – The European GPS:

State of play of the European Global Navigations Satellite System and cooperation with Australia

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Vol.5 No.2 (April 2014)
ISSN 1838-0379

ANU COLLEGE OF ARTS & SOCIAL SCIENCES

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Galileo – The European GPS
State of play of the European Global Navigations Satellite System and cooperation with Australia

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The European Union is building up its own global positioning and timing system called Galileo, which is the only Global Positioning System under civil control. So far approximately EUR 6 billion has been spent on the research, development and deployment of Galileo. Four operational satellites have been launched and the next two are scheduled for September 2013. In the next financial projections (2014–20) nearly EUR 7 billion has been reserved for this project in the EU budget. In 2004 the EU has concluded a cooperation agreement with the US indicating, among other things, that the GPS and Galileo will be compatible and interoperable.

The global market for applications related to positioning and timing is estimated at around EUR 250 billion in 2020. Currently 6–7 per cent of the GDP of the EU and even more of the US already relies on services requiring positioning and timing (such as banking, electricity networks, agriculture and road systems). For some governmental services these are key capabilities.

Introduction

Global Navigation Satellite Systems (GNSS) have become an accepted part of life today. More and more applications rely on their functionalities and increasingly more economic sectors depend on the positioning, navigation and timing information they provide. The GPS (Global Positioning System) of the US has established itself during the last 30 years as the world's standard. Meanwhile, Russia, China and the European Union are building up their own global systems, known as GLONASS, COMPASS and Galileo respectively. This paper will look at the development of Galileo and its relationship to and cooperation with the various satellite systems. Special consideration will be given to Australia as this paper was developed during an EU fellowship at the Centre for European Studies at the Australian National University.

1. What is satellite navigation?

Navigation satellites broadcast signals which are picked up by a receiver to determine precisely their position, velocity and time. Satellite navigation is defined by the American Heritage Dictionary as a "system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver". Global Satellite Navigation Systems, usually comprise more than 24 satellites, with world-wide coverage, whereas Regional Satellite Navigation Systems home in on a given area producing more accurate coverage while working independently. Global and Regional navigation systems deploy the three operational components of a satellite system: space segment; ground infrastructure which provides command and control; and the user segment, comprising the end user or customer.

2. Brief history of satellite navigation

The US launched its original GPS satellite in 1978 as the first of a constellation of 24 satellites and reached full operational capability in 1995 (Constantine 2008: 4). The GPS was conceived, developed, controlled and financed by the US Department of Defense and is primarily a military system. Increasingly more military applications depend on it. For example about 60 per cent of all munitions used during the Iraq war were GPS-guided.[1] As a by-product GPS provides a civil signal available for the civilian customer which is not encrypted and consequently is freely accessible by the civil community. However the civil signal was for a long time controlled by the US and accessible on a "selected availability" basis because of the fear that this signal could be used by hostile users. It was only in 2000, that the White House decided to turn off the "selected availability", partly in response to the demands of commercial users, the precision provided by the Differential Global Positioning System (DGPS), and the threat of the EU's Galileo and Russia's GLONASS programs (Constantine: 7).

Russia had also developed its Satellite Navigation Program for military purposes as of 1982, but the full operational capability was only reached recently due to the fact that at

[1] For further information see Beidleman, 39.

the end of the last century Russia did not finalise the system and the space segment had only a very limited lifetime. GLONASS is coordinated by Russia's Ministry of Defence. China launched its first satellites for a regional system (Beidou) in 2000 and is now building up its global system (COMPASS). Again the systems are under military control and also provide a signal for civilian customers. Finally the European Union has started to build up its own global system (Galileo), which is the only civil system under civil control.

3. Galileo – the European GNSS and EGNOS (European Geostationary Navigation Overlay Service).

3.1 Brief History

The European Union's history of satellite navigation started in 1994 with a proposal for its engagement in Europe by the European Commission. Based on this proposal the Council of the European Union at the end of 1994 invited the European Commission to initiate the necessary steps (Special Report of the European Court of Auditors: 1). In this report, the development as well as the overruns in the timing and budget of Galileo, are well described. Initially foreseen to operate from 2008, full operational capability is now scheduled for 2019/2020. However it is interesting to note that in 2006, it was announced that GPS III would not be introduced "before 2012", but it is now scheduled to be introduced not before 2020 as well. It should then provide comparable services to Galileo. By this timing a window of opportunity for the Galileo services of four to five years would be provided (Beidleman 2006: 44).

In relation to the budget needs for building up the GNSS in the US, compared to those of the EU, Pietka and Urrutia provide some interesting information. In 2006, an estimated $US26 billion was needed for building up the GPS. This figure was updated in 2009 to approximately $US40 billion. Up to 2013 Galileo's and EGNOS' expenditure was approximately EUR 5.6 billion. However, a further nearly EUR 7 billion has been estimated as necessary for "Full Operational Capability" in 2019/20 to be achieved. This highlights the difficulties of mastering, in terms of budgeting and timing, these cutting edge technology projects.

The Galileo program has changed its governance structure over time. Initially conceived as a Public Private Partnership (PPP) it has taken the European Union a long time to 'reprofile' the program, and it was only in 2008 after the failure of the PPP, that the Council of Ministers and the European Parliament decided to finance the European GNSS programs exclusively through the Budget of the European Union.[2] This reprofiling had far-reaching consequences for countries already participating in the European programs, because Galileo became a truly European infrastructure project under exclusive European control. Countries like China and Israel had to redefine their participation – and this was not an easy task. On the other hand, the reprofiling has considerably lowered the concern of the US government. Worried about the European Initiative and also about Chinese participation in the Galileo program, the US position until 2008 is well defined by both Beidleman and Constantine.

Since 2010 the National Space Policy of President Obama states: "Engage with foreign GNSS providers to encourage compatibility and interoperability, promote transparency in civil service provision...". Since 2004 and the conclusion of the EU-US agreement on GNSS, the EU has engaged in constructive dialogue with the US, and since 2011 looked beyond the purely civil service provision. In this context the definitions of Compatibility and Interoperability, as used by the International Committee on Global Navigation Satellite Systems, are important:

> Compatibility refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference and/or other harm to an individual system and/or service, ie "do no harm".
>
> Interoperability refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide, to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system, ie "combine".

3.2 Reasons for a European GNSS and governance

The EU has four main reasons for building up its own GNSS system:

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[2] See Regulation (EC) No 683/2008 of the European Parliament and of the Council of 9 July 2008.

- Political: to affirm EU independence and mark its place in the international scene;
- Social: to provide new and/or better services to the citizens, improve safety and benefits related to the environment;
- Economic: to increase market share and achieve global competitiveness in all segments of the value chain; and finally
- Technological: to foster leadership of the EU industry and benefit from synergies between technologies.

The European GNSS program consists of two parts – the EGNOS program, which provides a regional system; and the Galileo program, which will provide worldwide coverage.

The European Commission is the Program Manager under the political oversight of the Council of the European Union and the European Parliament. The European Commission is supported by the European Space Agency (ESA), responsible through a delegation agreement for the handling of development and deployment of contracts, and the European GNSS Agency (GSA) is in charge of market preparation and security related aspects.

3.3 EGNOS

EGNOS is the European Geostationary Navigation Overlay Service. It is the first pan-European satellite navigation system. It augments the US GPS satellite navigation system and makes it suitable for critical applications such as flying aircraft or navigating ships through narrow channels. It improves the accuracy of position measurements by sending out signals that correct GPS data, and provides information on its reliability.

The architecture of EGNOS is composed of three geostationary satellites, covering Europe, the Middle East and Africa, as well as of a number of Ranging, Integrity and Monitoring Stations, Mission Control Centres and other facilities. EGNOS provides corrections for GPS orbit and clock errors and for ionosphere error. In terms of typical orders of magnitude, the horizontal positioning accuracy error of GPS is reduced in such a way from 5.08 metres to 1.84 metres. EGNOS is performing with nearly 100 per cent

availability.[3]

EGNOS provides three long-term services:

- the open service: the open signal of EGNOS is provided free and was declared operational on 1 October 2009.
- the safety of life service: with an accuracy of about 1 metre and compliant to aviation standards. This service has been available to users since March 2011.
- the commercial service –EGNOS Data Access Service (EDAS): with an accuracy below 1metre and corrections provided by terrestrial networks. This service has been available since July 2012.

3.4 Galileo

Galileo was conceived to provide five services:

- the Open Service (OS): free to air, aimed at mass markets in need of simple positioning;
- the Public Regulated Service (PRS): with an encrypted signal, this service is very robust and will be available continuously;
- the Search and Rescue Service (SAR): this service will provide in near real-time a return link with precise location;
- the Commercial Service (CS): this encrypted and highly accurate service will bring added value to commercial users; and finally
- the Safety of life (SoL) Service: which will add integrity to the open service.

Three of these services (early OS, SAR and PRS) will be provided by 2014/2016. Within the discussions of the new Regulation of the European Parliament and of the Council on the implementation and exploitation of European Satellite Navigation Systems covering the period 2014 to 2020, it is foreseen that the SoL service should be reprofiled in order to ensure interoperability with other GNSS Systems, respond effectively to safety-of-life users and reduce the complexity, risks and costs of the required infrastructure. Galileo will be implemented in a step-wise approach. Two test satellites were launched in 2005 and in 2008 in order to secure Galileo frequencies and to test technologies in orbit. In

[3] See CNES User Guide for EGNOS application developers.

2008 the first passive hydrogen maser (microwave amplification by stimulated emission of radiation) clock has been sent to space.

On the 21 October 2011, the first operational Galileo satellites were launched from Kourou in French Guyana, followed by another two on 12 October 2012. The next launch was scheduled for September 2013 and “Initial Operational Capability” should be reached in 2014 with an 18 satellite constellation. The ground network has been built up in parallel, consisting of two control centres, one service centre and a number of other stations around the world.

3.5. International Strategy

International cooperation is crucial for the European GNSS development. The EU would like to achieve compatibility and wherever possible interoperability with other GNSS Service Providers. The uptake of EGNOS should be fostered where appropriate and that of Galileo fostered worldwide. Bilateral and multilateral efforts are important to achieve the objective of cooperative agreements. A number of GNSS cooperative agreements have already been concluded: China (2003), the United States of America (2004), Norway (2010) and others. Agreements with Russia, Japan, India and Switzerland are under discussion. Cooperation areas covered by these agreements include, for example, compatibility and interoperability, security, trade matters, standardisation, applications and research. The extension of EGNOS coverage to Africa also requires substantial effort.

3.6. Applications

The global market of GNSS applications is increasing steadily. Estimated at EUR128 billion in 2008 it is expected that this market will have doubled by 2020 with a yearly increase of around 11 per cent on average. Mobility in general will benefit most of the services provided. Location-based services and Intelligent Transport Services for road will represent over 90 per cent of this market. Other domains include precision agriculture, sea and air transport. It is estimated that EGNOS and Galileo will provide

cumulative indirect benefits of around EUR 60 to 90 billion to the EU over the next 20 years.[4]

The GNSS market is not a traditional market, because other GNSS service providers support civil applications by the military component of the GNSS and in such a way provide substantial research and development support. The uptake of the EU GNSS based applications is presently rather low because of the time frame needed to have Galileo up and running. There was a high cost for the failure of the Galileo PPP model in the past. EU funds for Galileo and EGNOS have been used nearly exclusively for building up the system and only to a very small extent for market development, despite various calls, especially from the European Economic and Social Committee, to invest more into the application sector.

For all these reasons the European Commission has taken action in order to:

- allow European industries to take an appropriate share of the worldwide GNSS application market (usually 33 per cent in high tech sectors compared to 20 per cent at present);
- protect the economic activities relying on GNSS services in Europe which are estimated at 6-7 per cent of the GDP of the European Union.

The Action Plan for GNSS applications was decided in 2010 and the European Commission has now promulgated a consultation on its update covering the period beyond 2014. Cross-cutting actions like setting up a virtual information centre and the development of synergies with other EU programs like Kopernikus, are combined with specific actions aimed at promoting LBS (Localisation Based Services) applications, and applications for the road market as well as other targeted sectors.[5] Ongoing public consultation can be found at www.europa.eu/entreprise/policies/satnav/pubconsult/index_en.htm.

[4] See Roland Berger, GSA analysis 2010.

[5] See Doc SEC (2010) 716 of the European Commission of 14.6.2010.

While it is proposed that some of the outcomes of the action plan of 2010 are to be continued there are also new proposals suggested for discussion:

- Option 3.1: the European Union decides to mandate that all critical infrastructures which rely on satellite navigation systems are Galileo enabled. This way the critical infrastructures can continue to function should a foreign GNSS fail;
- Option 3.2: in addition to option 3.1, this option would provide that the European Union mandates the use of Galileo-enabled systems in some critical and regulated activities (e.g. transport of dangerous goods, fishing vessels)
- Option 4: The European Union requires that any receiver that is marketed in the EU is Galileo enabled. This way, all equipment using GNSS technology on the EU territory can make use of Galileo, in particular in the case of the failure of the other GNSS systems.

These proposals are aimed at increasing safety and security on EU territory and should also ensure that the largest possible use of Galileo is made in combination with other GNSS, especially with the GPS. However the underlying concept may also be understood as a mechanism to make sure that Galileo has a clear and level playing field for market uptake in the European Union. It is interesting to compare this proposal with the existing legislation in Russia and China where both those countries require the use of their respective systems on their own territory.

4. Galileo and Australia

Australia does not have its own global or regional satellite system. However it operates and maintains GNSS networks of approximately 100 Continuously Operating Reference Stations (CORS) across the Australian region and the South Pacific, including:

- Australian Regional GNSS Network;
- South Pacific Regional GNSS Network; and the
- AuScope network. [6]

It has been suggested in the Satellite Based Augmentation System Review of May 2011 that at this time, on the basis of information currently available, it is difficult to justify the significant investment involved in establishing SBAS (Satellite Based Augmentation System) in Australia to cover aviation operations at smaller aerodromes. Other

[6] See Australian Government, Geoscience Australia web page.

technologies are used by land and maritime transport, and agriculture industries “to meet their needs” (e.g. using ground based augmentation systems for horizontal guidance).

Against this background the Australian Government released on 9 April 2013 Australia's Satellite Utilisation Policy. Major pillars of this policy in the context of this paper are that Australia:

- aims to achieve “ongoing cost-effective access to the space capabilities on which the nation relies now and in the future”;
- recognises the present dependence and ever-growing importance of space capabilities for Australia;
- recommends that it should “develop its nascent and growing capabilities and use them to strengthen international relationships”;
- defines a set of space applications of national significance including positioning, navigation and timing;
- supports innovation, science and skill development;
- defines the objective to protect and enhance national security and economic well-being; and
- aims at improving domestic coordination.

It is foreshadowed that by 2020 the skies above Asia and Australia will be one of the most widely covered parts of the world in terms of satellite visibility at any time of the day. Following the analysis done by Dempster and Rizos (2009) between 40 and 50 satellites will be visible in that region, which far exceeds those in the US or in the EU. Australia will therefore become highly privileged in terms of satellite coverage. However this advantage can only become a reality if the global and regional systems are compatible and interoperable. So Australia as well as the whole region has a fundamental interest in supporting the Galileo and GPS strategy that receivers are developed capable of receiving and using signals emanating from several GNSS and regional systems, wherever possible and appropriate.

Galileo is interoperable with GPS. Each satellite the EU puts up into the sky will improve the coverage of Australia and enable greater precision in this continent, if the receivers are equipped with the appropriate chipsets. This should not represent a major investment. However more research into this segment would facilitate uptake and favour-related

applications.[7] Another example of the scientific capacity of Australia is the development of the new antenna calibration facility, which will improve the accuracy of satellite positioning technologies up to sub-millimetre accuracy.[8]

As of 2014/2015, the first Galileo services will be available for Australia free of charge. Galileo services will come with quality and integrity guarantees which mark the key difference between this first complete civil positioning system from the military systems that have come before.[9] Australia would need to be assured of access to the Public Regulated Service, in terms of a service guarantee, covering its encryption and reliability in time of crisis situations. One should be reminded that this service is reserved for government authorised users within the European Union, following Decision No. 1104/2011/EU of the European Parliament and the Council of 25 October 2011 on the rules for the access to the public regulated service provided by the global navigation satellite system established under the Galileo program.[10] However following article 3 paragraph 5 of this decision third countries or international organisations may become PRS participants, when an international agreement is concluded on security of information as well as a specific agreement laying down the terms and conditions of the detailed rules for access to the PRS by the third country or international organisation. Australia and the EU have already concluded a security of information agreement and the Defence White Paper 2013 of the Australian Government (see point 6.78) provides a basis for discussions between the EU and Australia, when it highlights that "NATO and the European Union will continue to be important in leading responses to crises within Europe's region of strategic interest. Australia's defence engagement with these organisations will focus on understanding the dynamics within them and developing our capacity to work effectively with them where it is in Australia's national interest to do so".

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[7] See R. Merrett about a project of Curtin University, funded by the Australian Space Research Program, just to give one example.
[8] See Don Farrell, Media release of 20 May 2013.

[9] See http://www.esa.int/Our_Activities/Navigation/The_future_-_Galileo/What_is_Galileo.
[10] See Official Journal of the European Union L 287/1of 4.11.2011.

5. Potential actions which might be in the interest of Australia

The European Union is presently concentrating nearly all of its resources on building up European GNSS infrastructure. The schedule is very tight and budgets are stretched. The full deployment of Galileo, including its security, will remain a strategic priority of the EU for the years to come. This is also valid for ESA, the GSA and the European industry. For applications and the promotion of the uptake of Galileo services the resources remain limited and are concentrated within the GSA. The activities on International Relations are presently concentrating on the main service providers of GNSS services (US, Russia and China). Relations with other countries do not receive the same level of attention – even with countries which are building up their own regional system (ie India and Japan). Australia was ranked by Gullish and Vaccaro[11] as an emerging nation and will have to look actively for ways and means of improving the service level for itself. Australia's Satellite Utilisation Policy has paved the way for better usage of the available GNSS constellations and the regional systems.

Conclusion

Australia is well positioned in space research (s.a.) and should actively pursue GNSS related research with the GSA concerning GNSS applications. The EU and Australia have a long and successful history of cooperation in research and innovation, and this cooperation is underpinned by a bilateral agreement for science and technology dating from 1994, which was the first such agreement signed by the EU. The European Commission has published a consultation paper on future EU support for GNSS applications, and Australian industry, the universities and the Australian Government are invited to forward proposals in this context.

In view of the compatibility and interoperability features of Galileo appropriate chipsets are needed and should be used in Australia in order to capture the GPS and Galileo signals in Australia. Australia should support this policy in international fora like the International Committee on Global Navigation Satellite Systems and the International Telecommunication Union, the United Nations specialised agency for information and

[11] See J. Gullish and D. Vaccaro, The Top Ten in PNT- National Space Competitiveness in 'Inside GNSS', November/December 2009, 42.

communication technologies. Australia holds a unique geopolitical position in Asia and the southern hemisphere in order to track and trace satellites and it already provides these services for other GNSS systems as mentioned in its Satellite Utilisation Policy. The EU has yet to decide to what extent and under what circumstances an offer from Australia might be of interest for them, especially with regard to security requirements.

Finally Australia could explore the usefulness and importance of PRS for its own forces. In view of its functionalities and restricted access Australia could ask, in the first round, for exploratory talks with a view to more detailed examination into the extent to which, and under what conditions, this governmental service would be of interest for its police, civil protection and military forces.

Abbreviations

CNES	Centre national d'etudes spatiales
DGSP	differential global positioning system
EC	European Commission
EGNOS	European Geostationary Navigation Overlay Service
ESA	European Space Agency
EU	European Union
GLONASS	global navigation satellite system (Russian)
GNSS	global navigation satellite system
GPS	global positioning system
(USA) LBS	localisation based services
NATO	North Atlantic Treaty Organization
PRS	public regulated service

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