Galileo: Current Status, Prospects and Applications

Vidal Ashkenazi

Nottingham Scientific Ltd
Loxley House, Riverside Business Park, Nottingham NG2 1RT, UK
Phone: +44 115 9682960, e-mail: vidal.ashkenazi@nsl.eu.com

Abstract. This article is the written version of an introductory presentation made at the Opening of the Workshop session entitled "Satellite Navigation: Prospects and Applications". The paper describes the present GNSS scene, which has changed significantly with the successful launch of GIOVE A, the first Galileo test satellite. A summary description of the planned modernisation and governance of the two existing global systems, GPS and GLONASS, is followed by brief details of the proposed Galileo Public-Private-Partnership (PPP) scheme, and a brief summary of the various regional Space Based Augmentation Systems (SBAS). The paper then concentrates on the proposed control of operations and governance of Galileo, a summary of the proposed Galileo services, and the applications that are likely to emerge in the near future.

1 Current GNSS Scene

With Galileo in its Development and Validation Phase, the future developments in GPS IIF and GPS III, the renewed interest in GLONASS, and the satellite navigation initiatives in Japan, China, India, Australia and several other countries, GNSS or Global Navigation Satellite System, is moving from being a concept, largely based on GPS alone, to a full global reality. To describe Galileo in its proper context, it is important to start with an overview of the current status of GNSS.

At present, GPS is the only fully operational global satellite navigation system. Despite its advancing age and unparalleled success of GPS, until recently the basic system had changed very little, since its inception in the 1970's, in terms of orbits and signals. In 1998, the White House announced the addition of a second civil GPS signal to improve the accuracy and reliability of GPS for civilian users. This was followed in 2000 by the removal of SA (Selective Availability).

These were the first steps in a comprehensive programme of GPS modernisation, which is currently underway, and aims to deliver significant improvements to both military and civil users. The programme covers modernisation of the space and control segments, including improved signals and stricter monitoring, which together will deliver a significantly improved performance to all users.

The first batch of Block II-F (Follow on) satellites will be in orbit in 2007 (or as recently announced in 2008), still one or more years before the European Galileo satellite system becomes operational. This space segment upgrade, coupled with several ground segment improvements, leading to increased accuracies of satellite orbit

positions and clock data, will result in a much enhanced user positioning performance. For dual frequency civil users, the resulting navigation accuracy could be as good as one metre.

The US Department of Defense is also planning to incrementally upgrade and improve the system, through a process which is known as GPS III, which will address the future needs of military and civil users over the next 30 years. As a result of extensive consultations with industry, academia and users, there is a substantial amount of information in the public domain on the proposed and planned features of GPS III. However, one would expect that the final configuration and full specifications of GPS III will not be defined until 2008, or soon thereafter, when Galileo-1 is due to be fully deployed and declared operational. Only then will one be able to assess fully the capabilities and the resulting commercial advantages of Galileo, from the point of view of service providers, government, receiver manufacturers, safety critical transportation users, and ordinary citizens. By then one would also have a clearer idea on the uptake of PRS (the so-called Public Regulated Service) of Galileo, and especially the penetration of the Commercial Service into the mass-market commercial applications, on a global basis. This is when the US will show its full hand, or most of it, and define GPS III.

The Russian GLONASS system is also undergoing an extensive Programme of Modernisation, with several recent successful launches of GLONASS-M satellites, to supplement the current constellation. This will be followed by the GLONASS-K satellites, which will be launched over the period 2008-2015 and are expected to be operational until 2025. GLONASS is now controlled by ROSKOSMOS, with an Interagency Coordinating Board, which involves several ministries, including Transport, Defence, Industry and Energy. This is not unlike GPS, which is now directed by an Executive Committee of Positioning, Navigation and Timing (PNT), co-chaired by the DoD and the DoT, and including representatives from the Departments of Commerce, State, Homeland Security, the Joint Chiefs of Staff, NASA and other government departments and agencies, as required. This is in sharp contrast to Galileo which, for the time being at any rate, is controlled by the Galileo Joint Undertaking (GJU) on behalf of the European Commission (EC) and the European Space Agency (ESA). However, this will change soon.

2 Galileo Prospects

Much has already been written about Galileo which, at present, is in its Development and In-Orbit-Validation phase. This will be followed by Full Deployment and start of Operations sometime around 2010 or soon thereafter. Galileo is Europe's initiative to develop a civil global navigation satellite system, which will provide highly accurate and reliable positioning, navigation and timing services. Galileo will be compatible and interoperable with GPS and GLONASS, and will offer multiple civil frequencies. Galileo will also provide instantaneous positioning services at the one-metre level as a result of improved orbits, better clocks, and dual frequency enhanced navigation algorithms.

Through its different services, Galileo will also offer a level of guarantees of service availability, and will inform users within 6 seconds of a failure of any satellite.

This will allow the system to be used for several safety-critical, mission-critical and business-dependent applications. The combined use of Galileo, GPS and GLONASS will offer a very high level of performance for a large variety of user communities and businesses. In its present configuration, the Galileo design is comparable to GPS Block IIF which was defined in 2000. The European Space Agency has now tabled a Proposal for the Evolution of the European GNSS Programme, call it if you wish Galileo-II, for consideration by the Member States, but these are early days. Unlike GPS, which is fully funded by the US Department of Defense, that is the tax payer, Galileo is expected to be funded and evolved through a PPP (Private-Public-Partnership) scheme, which is still to be fully fleshed out.

3 Regional Augmentations

In parallel to the development of the 3 global satellite navigation systems, there are also several initiatives to develop satellite augmentation systems. Space Based Augmentation Systems (SBAS) have been designed to provide the necessary levels of accuracy, integrity, availability and continuity from GPS (and GLONASS), in order to facilitate the migration towards a satellite-based, global navigation infrastructure. In recent years, there has been a significant interest in the development of SBAS by an increasing number of regions in the world. The US, Europe and Japan were the first countries to commit themselves to the development of a regional SBAS, and led the way with WAAS, EGNOS and MSAS. More recently they have been joined by India, and now there is also a variety of other SBAS trials which are being conducted elsewhere in Asia, Australia, Latin America, and Africa.

Additionally, some countries are designing or developing independent regional satellite positioning systems, based on geostationary (GEO) and/or inclined geostationary satellite orbits (IGSO). Most notable among these are the QZSS in Japan, based on 3 satellites with highly elliptical orbits (HEO), BEIDOU in China which is based on 3 GEOs, and IRNSS in India which is planned to include 3 GEOs and 4 IGSOs. Lastly, China is proposing to have its own global satellite positioning system COMPASS, which will be based on 24 MEO's, just like GPS and Galileo, and include a security signal which will operate on the same frequencies as Galileo's PRS.

4 Galileo Operation and Governance

The European Galileo Project is moving ahead, and preparing to face the many current and future challenges. Over the last 18 months, the Galileo Joint Undertaking (GJU) has carried out an extensive process of inviting competitive tenders for the Galileo Concession, selecting and merging of the two "preferred bidders", and the submission of a single proposal by the merged Consortium followed by negotiations. Meanwhile, a new licensing authority, which will manage the interests of the public sector vis-à-vis the Concessionnaire, in relation to Galileo and EGNOS, has been set up. The Galileo Supervisory Authority (GSA), which will take over the activities of the GJU by the end of 2006, will not only supervise the private concession holder, which will be known as the Galileo Operating Company

(GOC), but will also contribute to the development of equipment and applications through the licensing of intellectual property rights (IPRs) vested in it. The day-to-day control and operations of Galileo will be carried out by the Galileo Operations Company (OpCo), which will manage the system and services on behalf of the Galileo Concession Holder (GOC), under contract. Like all the other global, regional and local satellite navigation systems, Galileo is all about applications. This is where the real challenges lie ahead. With GPS the civilian community was offered a free signal, with no guarantees whatsoever, whether on performance, integrity, coverage or continuity. Nevertheless, the all pervasive human ingenuity came along and provided a variety of tools to overcome the drawbacks of standalone GPS. These ranged from the development of differential GPS (DGPS) and carrier phase or kinematic GPS, which offered users centimetric and millimetric accuracies, to wide area augmentation systems, like WAAS and EGNOS, which improved integrity. These developments led not only to mass market, scientific and professional applications, but also to the development of safety-critical transportation applications, such the landing of civilian aircraft and the docking of ships entering harbour.

5 Proposed Services and Applications

With the impending arrival and start of operations of Galileo, there will a whole range of new applications based on the proposed 5 Galileo services, namely the Open Service (OS), the Commercial Service (CS), the Safety-of-Life (SoL), Search-and-Rescue (SaR), and the Public Regulated Service (PRS). These new applications will include business-critical, environmental-critical, financial-critical, legal-critical and government-policy-critical applications. Like GPS, the OS will cater for Mass Market applications, such as Location Based Services ("where am I?" or "where is the nearest . . . ?"), Telematics (fleet management, asset tracking, etc), and leisure (sport and recreation). Safety critical transportation, like the landing of airplanes and the docking of ships will be catered for by the SoL service. As the name indicates, the Galileo SaR service, which will also involve communications, will be used in emergency situations.

The precise role of the remaining two Galileo services, namely PRS and CS, is not yet fully defined. The declared intention is to use PRS for the police, security services, firefighting and ambulance services, where there is a need of additional integrity, coverage and continuity of the satellite signals. The CS will also provide the same degrees of integrity and coverage, but not necessarily of continuity, especially in emergency situations at certain geographical locations. However, the main difficulty of the CS is due to the fact that this will be the main Galileo service which is expected to generate the necessary financial returns for the Concessionnaire, so that the latter can fulfil its obligations under the Galileo Public Private Partnership (PPP) principle.

Among the potential candidate applications which could use the Commercial Service (CS), one could list Location Based Security (LBS), which would be used with portable PC's or laptops containing business sensitive data, and Galileo Time Synchronisation for time stamping of financially critical transactions and the synchronisation of data communication networks, including the world-wide-web.

Other potential CS user communities could include the offshore oil and gas industry, civil engineering and land surveying, and possibly the science and engineering community. All this would be subject, of course, to developing appropriate commercial services targeting the specific needs of these professional communities.

At present, it is not yet clear to what extent critical applications, such as Road User Charging (RUC) which is being seriously contemplated by the British government and has financially-critical aspects, Train Signalling which is safety-critical, and offender-tracking which is legal-critical will be catered for by the CS or the PRS. Furthermore, offender tracking, which will inevitably involve indoor as well as outdoor positioning, will require a suitable combination of High Sensitivity Galileo (HSG) with WiFi Local Area Networks (LAN). We are heading for interesting times, with ample opportunities for human ingenuity and enterprise.