Galileo – costs and benefits

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Contents

1 Introduction

The true story of Galileo begins not in June 1998 with ESA, EUROCONTROL and the EC signing "an agreement formalising co-operation between the three organistions in the field of satellite navigation systems and services, with the aim of establishing a satellite navigation and positioning service for Europe as a contribution to a global effort"[2], but before that, in 1996, when the same three organisations, driven by similiar motives, started out to build EGNOS, the European Geostationary Navigation Overlay Service[1].

In many ways EGNOS is the true forerunner of Galileo. It was devised on the realization that localization and navigation technology was evolving into a huge market segment – and that there was more to it than what GPS offered. EGNOS would add to GPS not only increased accuracy but *confidence* and *reliability*, two aspects that, in my opinion, will play a huge role in delicate business applications such as train or aircraft navigation (see [4]).

The second major role of EGNOS was to build Europe's credibility in the GNSS segment. For Galileo to work it was not enough to have the know-how but in order to get the international community involved Europe had to demonstrate that it was able both technologically and organisationally to handle a project of that magnitude.

While continuing in EGNOS' steps, Galileo will add another virtue: *independence*. This may be seen as solely serving the – for lack of a better expression – 'European national spirit', and that is admittedly part of the charm, but on the bigger scale I believe that the enthusiasm spawned in both European industry and European customers combined with the reliability and versality of the Galileo platform will lead to the projected considerable market growth.

In this essay I will try to explore the cost and potential of Galileo and the projected effects. Section 2 will analyze the funding of Galileo and the reasons for the respective parties to join. To strengthen the points made about Galileo's potential, section 3 will explore some outstanding proposed application. Finally, section 4 will conclude with the current state of events.

2 Who pays for Galileo – and why?

2.1 Cost division

The overall cost of Galileo is set at approximately 3.6 billion € (≈AUD 5.8 billion). It is comprised of the following parts:[1]

1. The **planning phase** will cost between 250 and 400 million € and is entirely funded by ESA.

   In this phase two test satellites (part of the Galileo System Test Bed GSTB) will be deployed by February 2006 to start the In-Orbit-Validation (IOV) and secure the reserved frequency bands. The first launch of GSTB-v2 A is sheduled for the 6th of December 2005.

2. The **developement phase** will cost around 1.1 billion € and will be funded by ESA and the European Union, more specifically the Transeuropean Networks (TEN). The biggests shares fall to Germany, France, Italy and Great Britain. Curious as it may seem, the Galileo project was held up in April 2005 when Spain rejected the budget because it had received a share of only 9% but wanted to pay more[2].

   This phase involves the deployment of 3 or 4 fully functional satellites and the complete setup of the ground segment, consisting of about 42 stations around the globe. The Galileo Joint Undertaking (GJU) is currently researching the planned integration of EGNOS – financially and functionally.[10]

3. The **deployment phase** with its considerable amount of between 2.1 and 2.25 billion € is funded through the 'Public-Private-Partnership' (PPP). This will involve the GJU selecting a consortium of companies and probably a public co-financing. At the moment, the GJU has reduced the number consortia running for Galileo concession to two: Eurely (mainly: Aeana, Alcatel, Finmeccanica and Hispasat) and

[1] Most data in this subsection is based on [7]

[2] The conflict was resolved by reducing the shares of Germany, France, Italy and Great Britain from 17.5% to 17.25%.

iNavSat (mainly: EADS Space, Inmarsat and Thales). A decission selecting one of the two was expected earlier this year, but appearently both offers where to good to refuse: "We have received two great offers. Both are so great that they deserved a serious negotiation."[12] The negotiations will continue and a winner is expected to be named before the end of 2005.[11]

This phase will produce a fully operable system of 30 satellites and will be finished in 2008 or in 2010 or 'before the end of the decade', depending on who you ask.

4. The **support phase** is expected to run with low expenses (around 150 million € per year) for the first six years. After that the possible replenishment costs will add to that so that support costs can range up to 400 million € in 2020.[13] While the support phase should be funded by the PPP it is possible that the European Union covers for the first six or seven years (about 1,000 million €).

Galileo is to be a civil undertaking. It is important, however, not to confuse 'civil' with 'commercial': major parts of Galieo are funded by the EU. So even if Galileo turns out to be a financial disaster and the private funding fails after Galileo is launched, the system is still an infrastructure investment of the EU – and the EU could no let it go to waste without loosing its face. (And that would contratict one of the main reasons for Galileo's contruction)

2.2 A perspective on the cost

The sum of 3.6 billion € sounds like an awful lot. To get a better understanding of what it actually means to the participants I have compared it to a few other expenses of the EU and the ESA:

- The budget for 2005 of the European Uniun lists 'Structural funds' with 37,247 million € and 'Administration' with 6,185 million €(!)[9]. The EU's share of Galileo is 550 million € for 2006 and 2007 and a possible 150 million € for 2007 to 2013. This results in an average of 675 million € per year, or a 1.7% increase in structural funds – hardly noticeable.

- In 2005, ESA had a budget of 2,977 million €.[5] With an average involvement of 135 million € per year this is also a rather small investment.

- To get a better picture of the value '3.6 billion €' I have looked up the usual price for one kilometer of motorway[3]: around 15 million €.[8] That puts the cost for the construction of Galileo at the cost for the construction of 240 km motorway. While Galileo uses that money over a period of five years (2003-2007: 48 km of motorway per year), the European nations together builds 1,200 km of motorway every year.[4]

2.3 Benefits of Galileo

The core question that stands since the announcement of Galileo remains: What benefits will it bring that make investments worthwhile? This question can be split into a number of smaller issues I will try to explore here.

Galileo vs. GPS There are a few technological improvements that give a pure-Galileo device a slight advantage over a pure-GPS device:

- 3 more satellites and a higher inclination improve availability, especially in areas closer to the poles (like Skandinavia)

- The use of two public frequencies will give Galileo a far better accuracy (1-4m), at least until GPS follows in that track

- Galileo will provide real time integrity messages from every satellite, reducing the 'Time to Alert' from up to 12 hours (GPS) to under 6 seconds (part of the Safety-of-Life service). Although currently there are a number of systems doing exactly that (SBAS, EGNOS, WAAS), Galileo will send these messages from every satellite thus increasing the availability of this service from the nowadays usual 95% to 99.5% and Galileo will supposedly be liable for errors in signal generation.[15]

[3]European motorway is usually made up of three lanes per direction

- The commercial service will offer the user the option to buy additional correction data (i.e. differential positioning information) and other region-dependant information (like up-to-date information about traffic conditions or hotels). While the latter is very consumer-oriented, the former makes sense for businesses that have to rely on very high accuracy around the globe: the guaranteed integrity and global availlability make Galileo superior to the existing augmentation services.

- Last but not least, the 'Search and Rescue' service will, for the first time, provide two-way communication with distress beacons while providing their exact location on the globe. This will aide in the prevention of disasters in remote areas and hopefully save us from future TV series like 'Lost'.

Galileo *and* **GPS** Altough Galileo alone offers a range of interesting services, the far more convincing arguments for using it are in the combination of both systems. The graphs show a simulation of the horizontal dillution of precision (HDOP) in a rural area (30 degree elevation mask) (from [16]):

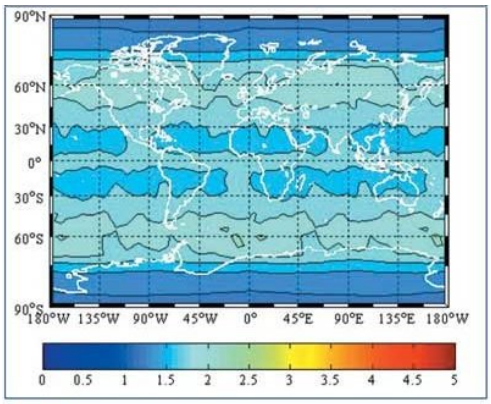

FIGURE 1 Global map of median HDOP over one day for GPS only using a 30° elevation mask and a height constraint

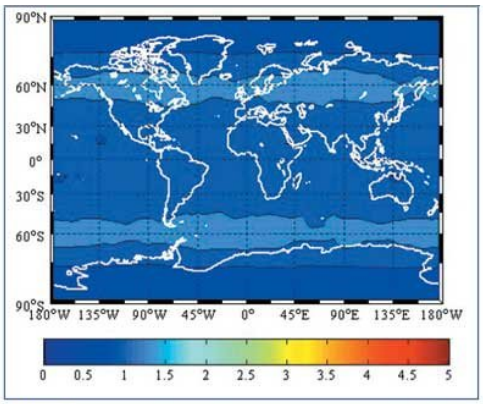

FIGURE 2 Median HDOP over one day for GPS/Galileo using a 30° elevation mask and a height constraint

It becomes clear that Galileo does not have to be much better than GPS to make it worthwhile: the mere presence of 30 more satellites improves performance so significantly that it enables completely new application. A GPS-Galileo device could, for instance, perform reliable traffic avoidance in highly built-up areas, using the combined accuracy of both systems and live traffic information from the Galileo commercial service.

3 Exemplary Applications

On its website ([19]), the 'Directorate-General Energy and Transport' of the European Commission presents a great number of possible Galileo applications. To strengthen the point that Galileo will create a market segment by enabling applications *that where not possible without it*, I will review some of the most outstanding applications here.

On the road While the mentioned applications in fleet management, theft protection,etc. are services operable with GPS as well, there are two application that use the new potential. The first is the concept of an **Advanced Driving Assistance System** which uses precise position to take partial or total control of the car in dangerous situations, for instance approaching a tight turn too fast. Naturally, such a system need to rely on extremely accurate and safety-of-life-reliable positioning which is offered only by Galileo. The second application targets **traffic management**, using a downstream through the commercial services to give navigation systems advice about where traffic jams are likely, by analyzing the speed of other cars equipped with Galileo receivers.

In the air At the moment, critical flight phase navigation depends on locally installed instrument landing systems (ILS). With safety-of-life integrity, commercial differential positioning information and in combination with GPS, Galileo positioning devices can reach realiable accuracy that brings a new dimension into aviation automation. Proposed application range from **automated ground navigation of aircraft** to **helicopter handling under extreme wheather conditions** – where a human pilot would not be able to hold the helicopter in position, an automated system based on high precision positioning has a big advantage.

Rail and water transport The navigation of maritime vessels off shore is possible using GPS only[4], but when it comes to harbour manoevers and in-

[4]Note however that currently there is almost no integrity information availlable since none of the great oceans are covered by the existing augmentation systems.

land waterways or train navigation, high accuracy and integrity are essential to bring automated transport to the next level.

Infrastructure monitoring In my opinion one of the more creative applications, infrastructure monitoring involves attaching a great number of GNSS receivers to a large construction (like a bridge or a large building) and monitoring their relative position to discover problems of structural integrity.

It is important to note that this list only covers about one third of the applications to be spawned by Galileo: the ones that were not possible before. Additionally, there will be those application that will result from the increased customer base due to the added availability of GPS and Galileo and finally those created by developers inspired by the installation of a new system – especially europeans. The last is admittedly speculation but there are developments (like the 'fish finder', see [20]) that justify this hope.

4 Conclusion

Galileo will be more than another, slightly improved GNSS – at least for Europe. Being from Germany myself this is obvious to me, but I will try to make it more clear: The European Union is still much more of a community than a union and the domestic interests of the member states weigh heavily in the joint decissions. The fact that Europe attempts such a massive and truly international project is a huge step forward for international cooperation.[17]

On the other hand, Galileo will create a new market segment for applications that depend on high integrity, accuracy and reliability (like civil aviation) or live, region dependent information – whether it be traffic data, tourist information or the local music charts –, an area that is likely to attract many consumer's interest. This situation bears a number of similiarities to the evolution of PayTV. A lot of people seem to take pride in their access to the media and with the development of mobile technology, 'location-based entertainment' is sure to be a major player in the next decade.

Some may still ask: Is Galileo neccessary? The only honest answer to that question can be: no. But is that the point? Was the introduction of the microwave neccessary? For centuries, man had lived without it. But it spawned a new generation of food, mostly fast food, and today it is part of our every-day lives. Likewise, Galileo will not only be built to improve global positioning as it exists today but will, hopefully, make itself neccessary, through new applications depending on its new features.

At the moment, most of the projections are based on speculation and only one thing seems certain: Galileo will be built – and even if the financial side flops the EU will have no choice but to keep it in operation after spending so much on its independence from GPS (and the US). So to answer the central question whether Galileo can make money: I think the potential is there – anything beyond that only time will tell.

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