



GINA WORKSHOP

How can EGNOS and Galileo contribute to innovative Road Pricing Policy? First findings and proposals from GINA project

Brussels, 1 October 2010

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Rue d'Idalie 35
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Workshop summary

Workshop context and objectives

In March 2010, the GINA project launched a large scale Road User charging demonstrator in the Netherlands. The trials' objectives are to test the performance of European GNSS (e.g. EGNOS) and other GNSS-centred technologies proposed by the project to enhance RUC schemes based on satellite positioning as well as an overall assessment of capabilities of the system from different perspectives.

The aim of the GINA workshop was to show to selected stakeholders (public authorities, private road operators and industry) with an interest in Road User Charging the results of the GINA exhaustive trials and, in more general terms, to raise awareness of the possibilities offered by EGNOS and Galileo and the technology proposed.

EGNOS and Galileo. Characteristics and advantages of European GNSS

Following a brief tour de table by participants, Joaquín Cosmen from GMV provided an overview of the characteristics and advantages of European GNSS.

European society already depends heavily on GNSS technology for a series of everyday operations, e.g. car navigators as well as more critical aspects, such as, amongst others, air navigation and road user charging. And while the risks of GPS becoming unavailable are very small, it is important for Europe to develop an independent GNSS capacity for economic and political reasons.

As a first step, EGNOS is designed to improve GPS performance in Europe and make it compatible with highly demanding Civil Aviation Requirements. As a European implementation of interoperable Satellite Based Augmentation System (SBAS), its receivers can work in any other SBAS.

EGNOS offers three distinct advantages vis-à-vis current GPS: first, improved horizontal and vertical accuracy; second, position integrity and third, continuity and availability of service. With respect to applications such as civil aviation and road user charging, position integrity is an essential component.

EGNOS open service is already fully operational since October 2009 and provides a substantial performance improvement in Europe, free of charge. The full deployment of Galileo in the future will establish European independence, provide improved performances and services worldwide and, in combination with GPS, will offer a substantial advantage to users.

Deployment of EGNOS/Galileo: Status of the programme and the political context

As a follow up, Philippe Hamet from DG Enterprise, European Commission presented participants with the current state of play with respect to the deployment of EGNOS and Galileo.

EGNOS is expected to deliver its services over a long-term horizon of above twenty years. As mentioned before, the EGNOS **Open Service** has been fully operational since last year, while the **Safety of Life** and the **Commercial Service** (EDAS) will be made fully available at the end of 2010 and in 2011 respectively.

The full availability of the EDAS services will undoubtedly provide a real value added service to end users in the transport sector through the provision of real-time EGNOS data (RIMS observations and SBAS messages). Data collected to date suggests that, for the centre of Europe, the measured Horizontal Precision Error is consistently better than the requirements. The objective is now to extend this performance to Eastern Europe, Mediterranean countries and the Middle East. Depending on the extension area, technical implementation may involve either a homogeneous extension with deployment of additional RIMS or regional infrastructure including additional processing capabilities.

Concerning Galileo, the current implementation timetable foresees full deployment of satellites and services to be completed by 2016/2017. Galileo will offer five services: **open service**, a free mass market option; **commercial service**, an encrypted high accuracy, added value option; **safety of life service**, which will add integrity to the open service; **public regulated service**, an encrypted, robust service with continuous availability that will be accessible only to governments; and the **search and rescue service**. The Galileo Open Service will offer a horizontal accuracy better than 4 metres

The management of the EGNOS and Galileo deployment is entrusted to the European Commission. To this end, the European Commission published recently a three year GNSS Action Plan, whose main objectives are to develop new applications for Galileo and support EU downstream industry and to promote Galileo enabled chipsets for mass market. These objectives translate into 25 concrete actions that will be implemented with the assistance of the European GNSS Supervisory Authority.

EGNOS/Galileo: an option now to enhance new road pricing initiatives based on GNSS

The workshop proceeded with a presentation from Fiammetta Diani from GSA, who provided an overview of the **trends**, **opportunities** and **actions** with respect to GNSS road pricing.

Growing mobility needs, coupled with pressure on national budgets and increasing concerns over the environmental impact of road transport, has led to growing calls for a **better and more efficient use of existing infrastructure**.

Given that SatNav enabled vehicles are expected to increase substantially in the near future, important opportunities are being opened up to policymakers, industry and end users alike. The effective deployment of Galileo services in the near future could contribute to higher level of road safety (E-call and ADAS), quicker travel times and a reduction in congestion levels and related CO₂ emissions via a more efficient road network management.

According to Directive 2004/52/EC and Decision 2009/750 related to European Electronic Tolling System (EETS), the tolling system must be compatible with both DSRC and GNSS systems but GNSS is recommended for new systems due to its flexibility.

With respect to Road Network Management, GNSS offers a number of advantages: the **flexibility** to adapt as road networks/ traffic evolve; **cost efficiency**, given that it alleviates the need for toll gate infrastructure; a **holistic approach** to traffic management covering all roads and vehicles; **interoperability** in a pan-European system; **new business opportunities** for value added services.

Given that most receivers today are EGNOS-enabled and not more costly than non-enabled ones, EGNOS is already being taken up by some early adopters as in the case of ENI, the biggest Italian energy company with a fleet of 1500 trucks. EGNOS can help providing a guarantee of position, providing a **level of confidence** to the user. This was demonstrated by the MENTORE project, which tested and demonstrated the added value of EGNOS for the tracking and tracing for various applications (dangerous goods, livestock etc). The successful results have prompted a follow-up action called SCUTUM, which will deal with exporting Italian best practice on the transport of dangerous goods to France and Austria.

Concluding, she pointed out that a new call for Galileo applications has been launched and invited participants to explore the possibilities offered.

GINA innovative approach to GNSS and EGNOS for Road Pricing – Findings from the trials

During the last presentation, Sara Gutiérrez provided an in-depth explanation of the GINA trials and results.

The GINA project involved a large demonstrator of a GNSS-based RUC & VAS scheme using the Dutch ABvM system and requirements defined by real end users as a reference. The GINA project relied heavily on the use of position integrity as a guarantor of accurate charging. Two sets of trials were defined: the **exhaustive** trials and the **end-to-end** trials.

The objective of the exhaustive trials was to test the performance of the system proposed (based on the use of European GNSS (e.g. EGNOS) and other GNSS-centered technologies (geo-fencing based on position integrity)) for a reliable road user charging scheme based on the Dutch ABvM. It involved 2 vehicles driving for 4 weeks following pre-defined routes and using three OBU configurations, i.e. GPS only, GPS+CANBUS (odometer) and GPS+CANBUS (odometer)+EGNOS.

Three test routes were defined to be representative of the conditions to be envisaged by any Dutch driver, combining a large motorway section with some small roads in urban

environment and some tunnels, large numbers of narrow streets and numerous turns in urban roads, some tall buildings and urban canyons, in Amsterdam, the Hague and Rotterdam.. Each route, which was deliberately chosen to challenge charging performance, was repeated over 20 times, with some routes performed additional times where possible.

A large amount of data was generated and from the subsequent data processing, the overall conclusion of the exhaustive trials was that; first, GNSS is a **reliable tool** for different RUC schemes, second, the GINA proposed technology allows for distance-based charging with **good performances** and a simple, affordable solution; and third, European GNSS (e.g. EGNOS) and other GNSS centered techniques **improve performances and reliability**

Subsequently, Sara Gutiérrez proceeded with an overview of the **end to end trials**. Involving 100 vehicles driving freely for a period of six months by Arval customers, the objectives of the end to end trials are to first, perform a **functionality/usage analysis** by assessing the overall capabilities of the system from different perspectives (generating invoices, driver feedback etc) and second, undertake **an exhaustive performance analysis** for those variables with no need of a reference system. For the end to end trials, four municipalities involving large geo-objects have been identified as charging zones in Utrecht, Den Haag, Rotterdam and Nijmegen.

The trials are currently ongoing and will run until December 2010. The results will be presented at the second GINA workshop that will take place during the first quarter of 2011.

Questions & Answers

1) What is a system of guaranteed performances? How can you prove that your system is guaranteed?

[GINA] We consider that in a framework where requirements are well established, the demonstration (and certification) that the system fulfils those requirements is a key. In this context we have developed a technology whose main objective is to ensure the reliability of the charging. For this purposes we have included the position integrity technology that guarantees (as needed for civil aviation) that position errors are bounded with a very high probability. This guarantee of position may be used for guaranteeing the charging and, very in particular, to avoid false identifications of geo-objects that can provoke an overcharging; so we can then guarantee a protection to the user. It is true that while our system may use CANBUS information that allows a very good behaviour in tunnels and even in front of local interferences, any GPS based system as the one we propose cannot guarantee the correct charging in case of lack of GPS signals caused by global interferences or, even failures in GPS constellation.

2) Could you clarify why in the DBC monthly invoices the average charging error is better for the GPS-only solution (-0.44% than for the CANBUS solution - 0.57%) and there is one case (excluding deep urban) where the maximum overcharging is better for the GPS-only solution (0.10%) than for the CANBUS solution (0.13%)?

[GINA] First, it is important to emphasize that while a huge amount of data has been used for the overall statistics, the samples of the "aggregated data" are much smaller and the differences in the order of magnitude in the order of 0.01% cannot be considered to be significant. While further analyses are needed to establish final conclusions, the following explanation justifies this behaviour: During the process of counting distance within the geo-object, there is always a small delay that implies that

this distance is smaller than the real one. This is true for all configurations. Concerning the total distance computation the CANBUS solution is extremely accurate while GPS solution has some trend to overestimate. So when combining both effects (underestimation within GEO-objects and overestimation of total distance) the GPS solution may compensate both errors resulting in a smaller charging error.

3) Reference system. You are not using maps, however, even if using a very accurate reference system, how do you detect that you are inside a tunnel (for instance)?

[GINA] GINA has been defined to meet the definition of the Dutch system, where the use of cartographies is not allowed. The output of the very accurate and reliable reference system used is considered as the truth in order to compare the GINA OBU outputs with it as it includes a highly stable inertial system which allows for a very accurate position (within one metre) even in total absence of any GNSS signal during a quite long period of time (several minutes). If there was the case that another road followed the same trace on the surface that the one in the tunnel, determining whether our vehicle was in the tunnel or on the surface would be a little more tricky (e.g. would require to take into account the vertical coordinate of the reference system) but would also be possible. However, this was never the case in the GINA trials, so detection of tunnels was straightforward. We think that the use of this reference system together with the amount of kilometers travelled in a fully representative environment make the performance results obtained of a highly valuable, and we think unique, significance.

4) Security issues of EGNOS/GALILEO

[GINA] While a huge effort is invested in EGNOS and Galileo to ensure that they are compliant with highly demanding civil aviation requirements, it is also true that all existing GNSS systems are not robust enough in front of non-intentional interferences, jamming and spoofing. As a matter of fact this was one of the hot topics in the last ION-GNSS conference (one of the most relevant events related with GNSS worldwide). On the other side, it is important to say that current GNSS RUC systems didn't encounter till now major problems from this point of view. It is currently believed that security of GNSS based applications require specific mechanisms that go beyond the systems themselves and involve implementation of large scale monitoring systems for interferences/spoofing together with legislation and enforcement/prosecution. In the future, the use of signal encryption (that is not available in civil GPS nor in EGNOS) in Galileo will provide an added value in front of spoofing but the key risk of jamming will, as mentioned, need to rely on external systems.

5) What do you consider an affordable, simple OBU? Could you state a price?

[GINA] The solution proposed by GINA is a GNSS-only solution in the sense that it does not incorporate any external element which increases the complexity and cost of the solution (e.g. cartographies, additional sensors etc.). It is based on the use of sophisticated algorithms running onboard (and possibly car sensors, such as the odometer, which is already there to be used). So, practically any OBU (with a GPS receiver a small CPU and a GSM connection is virtually able to implement GINA technology. The GINA OBU implemented is based on a platform that GMV uses for R&D and its price is not representative of a commercial product. Of course the price of an OBU largely depends on the number of units to be manufactured.

6) Enforcement technologies are essential and even if the proposed solution is not expensive, enforcement elements will be increasing the price of the final solution

[GINA] The project has not focused on the enforcement solution but on the charging solution. The enforcement is a problem common to every free flow system, including DSRC based ones. This is not preventing the new trend toward free flow systems, that are much more acceptable by users. For sure, the enforcement elements will increase the overall price of the final solution but this will be occurring in a system which makes use of the GINA proposed technology or in other free flow system competing with GINA.

7) Does the system only calculate distance? Then, it would not be applicable to schemes where a detection of segments is needed

[GINA] GINA solution can be applied to both schemes. It is believed that the combination of distance measurement plus detection of geo-objects cover most of the foreseeable RUC schemes. It is very important to understand that the concept of geo-object detection is a generalization of the "road segments identification" that today is implemented in systems like the German Toll-Collect: every road segment will have an associated geo-object; although geo-objects cover also other concepts as an urban cordon. In any case GINA has been designed to satisfy the definition of the ABvM system, which is a very demanding scheme as it is a Distance Based Charging Scheme defining different tariffs for different roads or road segments. Therefore, detection of geo-objects (and segments as a particular case) is a key piece of GINA solution, which hence can be used for segment-based schemes by simply ignoring the distance computation functionality. In summary while the system has been designed to be representative of the Dutch system the proposed technology is targeted to provide a solution for different RUC schemes and for road and urban charging.

8) How costly the definition of geo-objects is? (in terms of complexity)

[GINA] We have highlighted the importance of the appropriate definition of the geo-objects for a satisfactory performance of the system. The elements to be charged are "officially" defined by the governments and this definition is implemented / programmed into the OBUs in the form of a geo-object (that it is not more than a geo-referenced polygon) with the degree of complexity which is necessary according to the technologies used and the performances expected (by the system) in terms of detection of geo-objects. In some cases that geo-object could be directly defined by the governments. The more complex you want the system to be, the more complex will be the definition of geo-objects, but this is a process that is carried out just once when the system is put into operation, with only minor changes and/or updates required since then on. As an example, the definition and validation of all geo-objects used (which are representative of the ones that would exist in the ABvM system) took less than 2 days