European Commission

Business Innovation Observatory

Space tech and services

Applications related to navigation – focus on Galileo PRS

Case study 62

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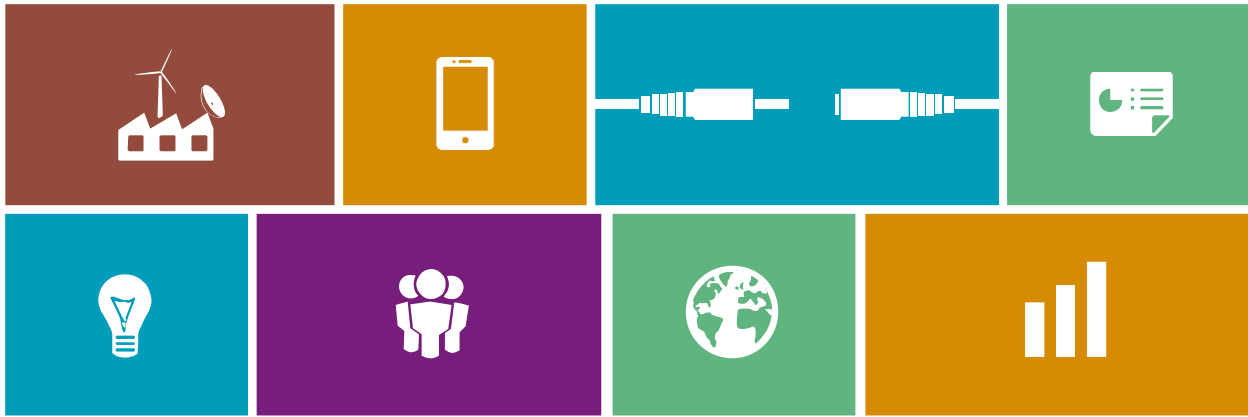Contract No 190/PP/ENT/CIP/12/C/N03C01

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1. Executive summary

Galileo is Europe's own global navigation satellite system (GNSS), providing a highly accurate, guaranteed global positioning service under civilian control. It is interoperable with GPS and Glonass, the US and Russian global satellite navigation systems. By offering dual frequencies as standard, Galileo is set to deliver real-time positioning accuracy down to the metre range.

The fully deployed Galileo system will consist of 24 operational satellites plus six in-orbit spares, positioned in three circular Medium Earth Orbit (MEO) planes at 23 222 km altitude above the Earth, and at an inclination of the orbital planes of 56 degrees to the equator. Initial services will be made available by the end of 2016. Then as the constellation is built-up beyond that, new services will be tested and made available, with system completion scheduled for 2020.

Among these services, the Public Regulated Service (PRS) is expected to bring a real added-value for strategic activities in Europe. Galileo PRS is a special Galileo navigation service using encrypted signals. This service aims at providing secured and robust positioning and timing for critical applications. Galileo PRS is expected to have a substantial impact on a wide range of strategic activities such as transport and emergency services, law enforcement, border control, peace missions but also critical infrastructure management. Given the high strategic value of the PRS for Member States, its use, but also the supply of related services and products, will be restricted to government-authorised entities. Member States will keep sovereignty on the selection and management of users and suppliers through a National PRS Authority.

Comparably to other GNSS services the impact of Galileo PRS is expected to be huge. Galileo PRS will add new layers to already existing GNSS services and significantly improve security, precision and quality of these services for critical

applications. Galileo PRS will also enable new services that less robust GNSS signals could not support yet. From a market perspective, an important industrial activity will be created to cover the supply of security modules, receivers and services. To answer this upcoming market, the European industry already engaged in developments of cutting-edge technologies for system architecture, cryptography, electronics and other related technologies. These Research and Development (R&D) activities are overseen and supported extensively by national and European public institutions.

Several obstacles will impact Galileo PRS market uptake. Because of its strategic importance, the PRS will give way to a highly regulated market. Supply activities will have to comply with stringent security and quality requirements and will have to respect strong export regulations. There are also significant technological challenges to enter Galileo PRS market. Some technologies required for the development of a complete PRS application require very specific skillsets. Finally, Galileo PRS core users will consist of governmental entities inherently difficult to access, which as a consequence reduces visibility on potential users' requirements and needs, which is an important barrier to assess Galileo PRS market.

While Galileo PRS is not yet operational, it is essential to lay the foundation for it already today in order to unlock the full potential of the service but also to ensure the emergence of a new European market. In this frame, market regulation impacts could be mitigated by providing visibility on security requirements and rules to potential suppliers. National PRS Authorities preparatory actions are also of the utmost importance and should be supported in order to speed up results. Procurement of core PRS services could also be organised at the European level despite national sovereignty in order to enlarge market and take advantage of scale effect to reduce costs.

2. Applications related to navigation

The trend "Space technologies and services" covers the latest developments in the space industry through four case studies. Each of them focuses on innovations related to space technologies and services fostered by the European Space Policy to tackle some of the most pressing challenges today. This paper explores the applications related to navigation through Galileo services, focusing on its Public Regulated Service.

2.1. Trend presentation

In the past, GNSS users worldwide had to depend on military systems: American GPS and Russian Glonass. With the launch of European Galileo satellites, users will be able to use a satellite-based navigation system which is run by civil, not military authorities. Galileo allows users to pinpoint their

"Galileo PRS provides a robust and resilient service. From this standpoint the GPS is not sufficient and Galileo provides a real added-value" – FDC

locations or the ones of other people or objects at any given moment. The range of potential applications is enormous. Applications span many domains, both public and private, from transport and logistics to communication applications, land surveying, agriculture, fisheries, environment protection, tourism and leisure and many more. It is also a very efficient instrument for activities like time stamping of financial or scientific research in meteorology.

Figure 1: Galileo logo

Source: Inside GNSS[1]

According to the European Commission, *"the Galileo System will be an independent, global, European-controlled satellite-based navigation system and will provide a number of guaranteed services to users equipped with Galileo-compatible receivers"*. Galileo will initially offer three high-performance navigation and positioning services from 2016 at the latest:

- **Open Service:** Galileo open and free of user charge signals set up for navigation and time services;

- **Public Regulated Service:** a special Galileo navigation service using encrypted signals set up for better management of critical transport and emergency services, better law enforcement, improved border control, and safer peace-keepingmissions;

- **Search and Rescue Service:** Europe's contribution to COSPAS-SARSAT, an international satellite-based search and rescue distress alert detection system.

In addition, a **Commercial Service** with enhanced quality is already being tested and is expected to be provided when the system is fully operational.

Galileo will enhance Europe's capacity to address major societal challenges. Among the various services, Galileo PRS will be a key feature of Galileo adding value over other satellite navigation systems.

The PRS is noteworthy as it will be encrypted and designed to be more robust than the other services, with anti-spoofing mechanisms and reliable problem detection. It is designed for sensitive applications as well as security and strategic infrastructure (e.g. energy, telecommunications and finance) which require a high level of service continuity.

According to the European Space Agency (ESA), the PRS will provide a higher level of protection against the threats to Galileo Signals in Space through the use of appropriate interference mitigation technologies. The need for the PRS results from the analysis of threats to the Galileo system. Galileo PRS is the solution designed for applications and infrastructure for which signal disruption could result in threats to national security, law enforcement, safety or economic activity.[2]

The PRS will be restricted to government-authorised users. Access will be controlled by through the encryption of the signals and the appropriate key distribution. Member States will also manage and control end-users as well as the manufacture of PRS receivers.

Anticipated PRS typical applications and users include:

- **Law Enforcement** (EUROPOL, Customs, Coast-guards, European Anti-Fraud Office - OLAF);

- **Security and Defence Services** (Europe's Common Security and Defence Policy – CSDP (European Union External Action), Maritime Safety Agency, Intelligence services);

- **Emergency Services** (peace keeping forces or humanitarian interventions).

Consequently, Galileo will offer new opportunities for the development of new space enabled applications, stimulating the creation of new businesses and markets.

European companies and Small & Medium Enterprises (SMEs) have demonstrated to be particularly suited to propose innovative applications **in the key GNSS segments of Road, Aviation, Location Based Services (LBS), Maritime, Rail, Agriculture and Surveying/Mapping.**

In components manufacturing, European companies are strong in Road, Rail and Aviation. For example Laird plc. has the widest application of components among European firms, with its antennas used in multiple market segments.

European companies are the global leader for system integration in Rail, and have a strong position in Maritime and Road. For system integrators, Hexagon AB (includes Leica Geosystems and Novatel) plays a key role in multiple segments.

Europe is also strong in development of value-added applications, with innovation being driven by SMEs and start-ups, among others. One of the priorities of the EU is to strengthen its economic value and competitiveness by creating opportunities for SMEs and using their potential for innovation. The experience of EU GNSS R&D projects proves that SMEs are especially strong in applications for fleet management, vehicle tracking and recreation/tourism.3

Despite the inherent difficulties related to restricted services, it is expected that PRS also follows this trend.

2.2. Overview of the companies

Table 1: Overview of the company cases referred to in this case study

Company	Location	Business innovation	Signals of success
FDC	France	FDC is an independent high technology research and engineering firm with a recognised knowledge of all positioning systems and technologies combined with in-depth experience of institutional aspects.	- Highly involved in Galileo decision-making processes - Actively involved in the two major Galileo-based industrial initiatives: OREGIN and Galileo Services - Contributes to a high number of GNSS services development projects
M3 Systems	France	M3 Systems is an independent SME specialized in high-performance navigation/positioning technologies for civilian and military applications.	- M3 Systems participated to a high number of R&D activities and studies for a wide range of institutions - M3 Systems developed its activities and now also addresses industry
Qascom	Italy	Qascom is a software and systems technology provider of applications in the satellite navigation and communications domain.	- Qascom has developed very specific and rare skills and now works for both institutions and industry - Qascom already owns several patents

Problem 1 – Preparing the floor and organising demand and supply is essential for a large European programme such as Galileo PRS.

Innovative solution 1 – Since the very beginning of GNSS, FDC has taken an active part in discussions on civil and military applications in Europe, firstly focusing on GPS use and now on Galileo adoption. FDC was also one of the initiators of the Galileo PRS.

Today FDC contributes to preparing the arrival of Galileo PRS through two support contracts. Contracted activities include the organisation of pilot projects, awareness actions and documentation preparation.

PACIFIC Workshop "Towards Galileo PRS, from Concept to Operational Use" organised by FDC

Source: FDC[4]

FDC also puts its unique 25 years' experience at the service of various customers R&D projects. In 2006 FDC decided to increase its own R&D activities targeting product development on a few focused domains, in particular Security and Maritime.

In this frame FDC participates to the development of navigation, communication and information innovative solutions and technologies.

Problem 2 – Maintaining the level of performance of Galileo PRS receivers in case of interference is essential to comply with security requirements

Innovative solution 2 – The development of solutions to guarantee Galileo PRS performance in case of interference is complex and involves various technologies and capabilities.

In this frame, M3 Systems has developed a test bed for simulation of interferences and assessment of their impact on performance and robustness of receivers.

This innovative solution is used for:

- Designing and evaluating innovative mitigation algorithms

- Generating intentional and non-intentional interferences

- Evaluating Galileo PRS signal and GPS code M signal

- Evaluating mitigation strategy (time, frequence, amplitude)

GNSS Interference Test-Bed
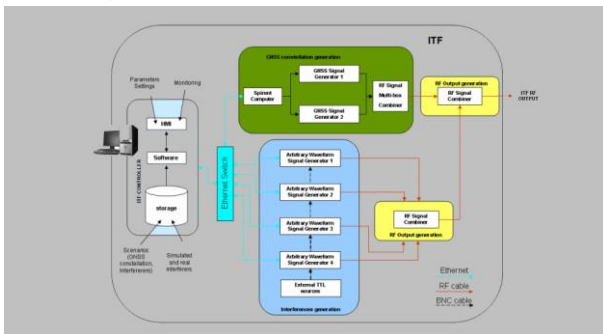
Source: M3 Systems[5]

Problem 3 – A part of potential Galileo PRS users are more flexible on security requirements and cannot offer the highest security grade products and services.

Innovative solution 3 – M3 Systems has contributed to various GNSS signal processing studies:

- Signal processing, modelling and prototyping: innovative receiver and algorithms

- Data Collection and Performance Analysis: signal, receivers, system flaws

- GNSS critical applications: specification, model, hybridization, integrity

- Embedded systems : Co-Design and methodology of HW/SW development

In the frame of a FP7 collaborative R&D contract, M3 Systems developed a low-cost tracking system for Galileo PRS. This study included the research activity but also the production of a prototype.

This innovation could open new low end markets in Europe.

GNSS signal processing studies
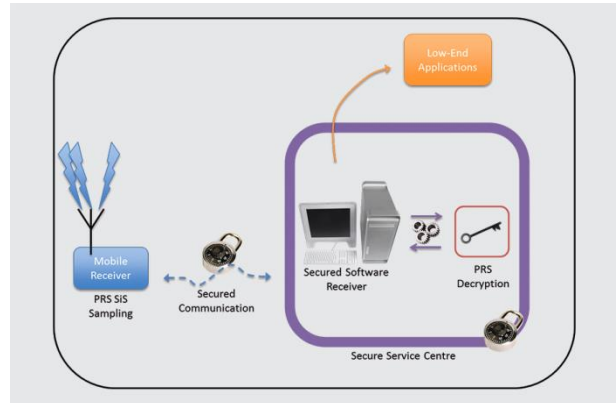
Source: M3 Systems[6]

Problem 4 – To improve signal security and robustness, Galileo PRS requires a signal authentication system.

Innovative solution 4 – Qascom offers a wide range of security engineering and vulnerability assessment services for communication and satellite navigation systems. In this frame, Qascom has developed innovative solutions for GNSS signal spoofing and jamming detection.

In the information security sector Qascom also offers technologies for Geo-Encryption and location based access control.

GNSS Security software solution

Source: Qascom[7]

Thanks to these innovative solutions for space and ground (user) segments, Qascom covers an large array of capabilities and technologies required for Galileo PRS signal authentication.

3. Impact of the trend

Initially launched for military purposes, GNSS revealed their potential when they started addressing civilian needs. Today GNSS are used daily by governments, businesses and citizens for a wide range of services and applications: automotive, transport and maritime navigation, timing, emergency positioning, monitoring and tracking.

The impact of GNSS on European economies and society is twofold:

- GNSS make existing public and commercial services more efficient. The substantial and positive impacts on traffic regulation or agriculture production are often pointed out as examples among many.

- GNSS are enablers of new services. They contribute to creating innovative public services and new business opportunities. Even after decades of GNSS operations, developments in other technology domains still lead to innovative solutions. For example, new applications for assistance to the elderly and the blind have recently emerged and already are promising.

3.1. The market potential of the trend

GNSS is used around the globe, with **3.6 billion GNSS devices in use in 2014**. By 2019, this is forecasted to increase to over 7 billion – for an average of one device per person on the planet.

Smartphones continue to dominate (3.08 billion in 2014), and are the most popular platform to access Location-Based Services, followed by devices used for road applications (0.26 billion). Other devices may be less numerous, but billions worldwide benefit from their application in efficient and safe transport networks, in productive and sustainable agriculture, surveying, and critical infrastructures.[8]

Figure 2 – GNSS market – Cumulative core revenue 2013-2023
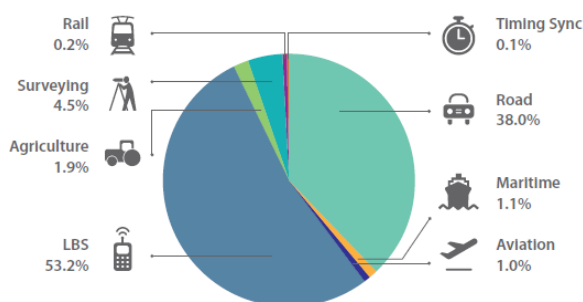
Source: GNSS Market Report[9]

The GNSS downstream industry is characterised by a **few very large companies and a plethora of SMEs**. The big players in the GNSS industry have embarked on multiple take-overs in recent years, implying consolidation at the top. In 2012, the top five companies by GNSS related turnover accounted for 34 per cent of turnover, and the largest company had 12 per cent of the global market.

The GNSS downstream industry is broadly classified into three groups of companies:

- **Components manufacturers**, producing receivers for stand-alone use or integration into systems, including chipsets, antennas and safety beacons.

- **Systems integrators**, integrating GNSS capability into larger products, such as vehicles and consumer electronics, as well as dedicated GNSS devices such as PNDs.

- **Value-added service providers**, whose services improve access and use of GNSS, including map providers, augmentation service providers and GNSS calibration or testing activities.[10]

The Galileo programme was launched when the European Union (EU) came to the conclusion that "Europe needed Galileo to be independent in a sector that has become critical for its economy and for the well-being of its citizens". Though Galileo was not designed to simply provide a European equivalent to existing GNSS. Galileo also offers additional or enriched services.

The European Commission estimates that "the global annual market for global navigation satellite products and services was valued at EUR 124 billion"[11] (in 2011). This already impressive figure actually represents only a fraction of the economic impact of GNSS and does not take into account the massive improvements brought across economic activities in terms of cost-efficiency, performance and quality. Still in 2011, "it was estimated that already 6-7 per cent of Europe's Gross Domestic Product (GDP), or EUR 800 billion, relies on satellite navigation applications".[12] **European companies account for one quarter of the global GNSS market.**[13]

The Galileo PRS will further enhance this impact:

- Galileo PRS will add new layers to already existing GNSS services and improve significantly security, precision and quality of these services for critical applications.

- Galileo PRS will also enable new services that less robust GNSS signals could not support yet.

As Galileo PRS market concerns all economic activities related to the additional security layer provided by Galileo PRS, the direct market is threefold:

- **Galileo PRS security module (SM)**: Galileo PRS receivers will be equipped with an additional security module. As a consequence Galileo PRS will contribute to the development of this new market for secured electronics devices manufacturers.

- **Galileo PRS receivers**: Additional security and product/quality assurance requirements and specifications will also be made applicable to receivers. Furthermore potential suppliers will have to be approved by national Galileo PRS authorities. Accordingly Galileo PRS receivers will involve a different supply chain.

- **Galileo PRS services**: The security, robustness and precision provided by the additional Galileo PRS signals are expected to enable a wide range of new services for critical applications.

According to PRS recent policy agreements, each Member State has sovereign power to elaborate both the lists of authorized users and suppliers. This strong market regulation, inherent to most strategic security domains, actually makes the potential market difficult to anticipate. According to the European Global navigation Satellite systems Agency (GSA), whose mission is to support EU objectives and achieve the highest return on European GNSS investment, *"there are around three million civilian security personnel (police, emergency services, etc.) in Europe, and the majority may require access to PRS. In addition other markets for PRS receivers may include secure timing and synchronization services for such critical infrastructures as banking and smart power grids".*[14]

Despite national regulations, an open European market can be expected for the most important products and services. An approach favouring national champions is likely to be adopted in some large European countries with operational industrial capabilities but is not conceivable in smaller Member States. Additionally, even the largest and most specialized Member States could not support the development of the complete set of competencies and technologies required to trigger the full Galileo PRS potential. For this reason it is likely that users from one Member State rely, at least partially, on the industry of another Member States.

In 2016 Galileo PRS will start a demonstration phase that already arouses enthusiasm of potential users who look forward to discovering the real potential of Galileo PRS. This enthusiasm is broadly shared by companies with relevant capabilities (electronics, telecommunications, security, etc.), investors and entrepreneurs who are confident in the business opportunities that Galileo PRS represent.

3.2. The social potential of the trend

Because of its objective to support critical applications, Galileo PRS social and economic impact in Europe is expected to be huge.

A robust and resilient signal is required today to guarantee the continuity of critical activities in Europe. From this point of view, Galileo PRS will significantly contribute to **improve the efficiency, security, performance and quality of existing European critical applications** such as law enforcement, maritime safety, customs or energy and telecommunications infrastructures.

Furthermore, Galileo PRS will almost certainly create **indirect and induced markets** related to the new applications enabled by this secured, resilient and precise timing and positioning service. Galileo PRS stringent security requirements stimulate the research and development of innovative architecture solutions and technologies to guarantee high security grades at lower costs. These solutions will open the way to new markets in other related markets such as maritime and automotive.

Within the direct value chain, comprised of PRS SM, receivers and service providers, Galileo PRS will contribute to maintaining and even generating a **high number of highly qualified jobs**. This is true for many domains of European excellence such as electronics, telecommunications, software and security.

4. Drivers and obstacles

4.1. A strongly regulated market makes market access difficult

Regulation and security requirements are a first obstacle to access the market. Discussions between Member States and European authorities (Council, Commission and External Action Service – EEAS) have led to a **decision on the rules for access to Galileo PRS.**[15]

According to this decision each Member State (or European authority) participating to Galileo PRS is granted independent sovereignty over the selection of PRS users and uses.

Additionally, each Member State will also assign the task of manufacturing PRS receivers and/or the associated security modules to bodies established on its territory or on the territory of another Member State.

Finally, each Member State shall ensure that its national security regulations offer a minimum degree of protection of classified information agreed at European level.

As a consequence Galileo PRS will give way to a strongly regulated market both from a user and supplier perspective. This is true for domestic, European and export markets. Such regulation limits market accessibility.

Furthermore, to ensure a high level of security and robustness to Galileo PRS, the selected contractors will have to implement stringent **Product and Quality Assurance (P&QA) requirements** and demonstrate compliance along the supply chain.

4.2. SMEs face technological barriers to enter Galileo PRS market

"Finding a partner with appropriate skills and able to reach a larger customer base is essential to introduce SME solutions on the market" –
Qascom

R&D and qualification/certification costs related to the development of a product for Galileo PRS are a second obstacle. Entering Galileo PRS market requires a substantial investment. **Technologies required for the security module (e.g. electronics, cryptography) are very complex** and only a limited number of European actors have developed proven solutions.

For this reason the emergence of integrated products/services provided by large manufacturers acting as national champions is foreseen. Nevertheless innovative solutions developed by smaller actors will contribute to enhance the benefits of Galileo PRS. For these actors, building sustainable partnerships with other companies or institutes is a key driver in order to be innovative and produce new products.

4.3. Limited visibility on the needs of users inhibits any assessment of the Galileo PRS market

According to EU decision, *"a competent PRS authority shall be designated by each Member State and EU authority"*. This national authority oversees Galileo PRS use by the Member State (access rights, keys, risk analysis) and reports to the European Galileo Security Monitoring Centre (GSMC) for security matters. A second objective of the national PRS authority is to ensure convergence between users demand and suppliers offers. From a market perspective this second task is essential and is undoubtedly the main success factor of Galileo PRS.

Galileo PRS core users will consist in governmental entities involved in strategic, critical or even secret operations. Such users are difficult to access by nature.

Developing and qualifying Galileo PRS products and services is a long process. For this reason it is important that suppliers understand the demand as soon as possible before Galileo PRS becomes operational. Understanding the potential market and its users is a key success factor. An early market assessment would allow a proper time to market for Galileo PRS solutions. Additionally, the development of products in line with users' needs would *de facto* contribute to market uptake and enhance Galileo PRS impact. Compartmentalization of users and suppliers would have disastrous effects on Galileo PRS market and eventually benefits.

From a technical point of view a series of factors such as geographical location, mobility, precision, security requirements or access to terrestrial networks will drive the demand. From this perspective, Galileo PRS users are diverse and their needs vary.

5. Policy recommendations

5.1. Improving visibility on future security requirements for Galileo PRS products and services suppliers

Regulation and security requirements are a first obstacle to access the market. Potential suppliers need a **good visibility and understanding of the rules and specifications** that will be applied. This is essential to:

- Evaluate if a compliance of their products with Galileo PRS requirements is achievable;

- Assess legal impacts and amortize related costs;

- Build appropriate partnerships;

- Prepare in order to reach compliance when Galileo PRS is operational.

*"Visibility on Galileo PRS framework is fundamental. It will allow suppliers to assess feasability, build partnerships and achieve appropriate time to market" – **M3 Systems***

A minimum degree of protection of classified information has been agreed at the European level. But more needs to be done on communication on this feature of Galileo PRS and on expected impact at supplier's level.

Moreover, at the national level, Member States should reach a decision on set of requirements and specifications to be applied to Galileo PRS suppliers. To be fully effective, this decision must then be complemented with a wide communication action.

5.2. Supporting National PRS Authorities in order to speed up the preparatory work

With regards to users management, setting up national PRS authorities was a significant first step through their contribution to:

- Increase awareness of potential users about Galileo PRS;

- Collect their needs and requirements;

- Share consolidated demand information with potential suppliers.

The actions of national PRS authorities are of the utmost

importance to lay the foundations for Galileo PRS. Therefore **supporting national PRS authorities is urgently required**.

The main way to do that is via reducing the huge amount of work performed at the national level. This could be done through joint action at European level such as the organisation of collective European Galileo PRS users and suppliers events.

*"Despite strong strategic interests and national sovereignty Galileo PRS products and services market will be European" – **Qascom***

Moreover, results at national levels could be monitored at the European level in order to guarantee the achievement of minimum objectives within deadlines of the Galileo agenda.

5.3. Organising core service procurement at European level

Member States reached the decision that Galileo PRS use and supply would be controlled and managed at the national level. Nevertheless, a part of user demand could be organised at the European level in order to:

- Identify commonalities between users' needs;

- Group users according to these common needs;

- Promote a range of generic products.

That would also have substantial positive impacts for both Galileo PRS users and suppliers across Europe.

Identifying common needs between European users, promoting generic solutions and supporting procurement is a key success factor for Galileo PRS. Pre-Commercial Procurement (PCP) and Public Procurement of Innovative Solutions (PPI) are particularly appropriate for Galileo PRS. The organisation of the demand at European level for a part of European users would be beneficial to all Member States willing to participate:

- Larger Member States could reduce their costs by enlarging the market and playing on scale effect;

- Smaller Member States could take advantage of this European platform to access high end applications and products;

- European suppliers would see their customer base enlarged.

Despite national sovereignty, **the organisation of a part of the demand should be performed at European level**. This would expand the market for Galileo PRS products and services allowing economies of scale and investment risk mitigation. Innovative solutions involving complete system architecture but requiring a critical user mass to become cost efficient could also emerge. Building on the capabilities of Member States and encouraging suppliers to specialise rather than engage in any unnecessary rivalries will improve public investment efficiency.

6. Appendix

6.1. Interviews

Company	Interviewee	Position
FDC	Pascal CAMPAGNE	CEO
M3 Systems	Willy VIGNEAU	Technical Director
Qascom	Alessandro POZZOBON	Co-founder

6.2. Websites

Company	Web address
FDC	http://www.fdc.fr/en/
M3 Systems	http://m3systems.net/
Qascom	http://www.qascom.com

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