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**IMPACT ASSESSMENT**

*Accompanying the document*

**Proposal for a Regulation of the European Parliament and of the Council on further implementation of the European satellite navigation programmes (2014 – 2020)**

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## DEFINITIONS

Commission	European Commission
Council	Council of the European Union
CS	Commercial Service
DG	Directorate-General of the European Commission
E0	Entity responsible for political supervision
E1	Single entity responsible for programme management
EASA	European Aviation Safety Agency
EDAS	EGNOS Data Access Service
EGNOS	European Geostationary Navigation Overlay Service
EGNSS	European Global Navigation Satellite System
ESA	European Space Agency. The ESA comprises 18 countries, two of which – Norway and Switzerland – are not EU Member States. Canada, Hungary, Poland and Romania take part in some cooperation projects with the ESA.
EU	European Union
European GNSS programmes	Galileo programme and EGNOS programme
FOC	Full Operational Capability (of the Galileo system)
GDP	Gross Domestic Product
GJU	Galileo Joint Undertaking
GLONASS	Global'naya Navigatsionnaya Sputnikovaya Sistema: a radio-based satellite navigation system operated by the Russian government
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite System
GNSS Committee	European GNSS Programmes Committee established by Article 19 of the Regulation (EC) No. 683/2008
GNSS Regulation	Regulation (EC) No. 683/2008 of the European Parliament and the Council on the further implementation of the European satellite navigation programmes (EGNOS and Galileo)

GPS	Global Positioning Service: a radio-based satellite navigation system operated by the US government
GSA	European GNSS Agency
ICAO	International Civil Aviation Organisation
IGO	Inter-governmental organisation
IOC	Initial Operational Capability (of the Galileo system)
IOV	In-Orbit Validation
ITU	International Telecommunications Union
ITU	International Telecommunication Union
Member States	Member States of the European Union
MPF	Multi-annual financial framework
MRD	Mission Requirements Document
OS	Open Service
PND	Personal Navigation Device
PRS	Public Regulated Service
SAR	Search and Rescue Service
SBAS	Satellite-Based Augmentation System
SoL	Safety of Life Service



## 1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

### 1.1. Identification

Lead DG: Enterprise and Industry

Other involved DGs:

Agenda Planning/WP Reference: 2011/ENTR/003

### 1.2. Organisation and timing

This impact assessment accompanies a legislative proposal for a Regulation of the European Parliament and of the Council on the further implementation of the European satellite navigation programmes (2014 – 2020). It follows the adoption of the mid-term review of the European satellite radio navigation programmes<sup>1</sup> in January 2011 that evaluates the current regulatory set-up and sets out the challenges ahead.

To make the most of the expertise available in other services of the Commission the impact assessment was elaborated in consultation with a steering group consisting of representatives of the following Directorate-Generals: SG, SJ, MOVE, ENER, BUDG, RTD, INFSO, JRC, HR, ENTR<sup>2</sup>. The steering group met five times (11<sup>th</sup> January, 14<sup>th</sup> February, 15<sup>th</sup> March, 15<sup>th</sup> April, and 27<sup>th</sup> June 2011) and was consulted on and agreed with the draft submitted herewith.

### 1.3. Consultation and expertise

#### *Consultation of external stakeholders*

This impact assessment is based on a number of consultations with a variety of stakeholders carried out between 2007 and 2011 on topics related to the **European Global Navigation Satellite Systems (GNSS)**. The extensive consultation process targeted different stakeholders and took various forms including:

- Thematic workshops and conferences with users of the future services;
- Interviews with members of the European GNSS programme committee, representatives of industry associations, experts from the downstream industry, experts from the European Space Agency and experts from the European GNSS Agency;
- Targeted working groups with participation of experts from the European Space Agency, experts from the European GNSS Agency and representatives of the GNSS programme committee.

Stakeholders were consulted on technical and legal issues, options for the provision of future services, marketing, cost evolution, risk analysis to options for future governance schemes.

Additionally, the general public was consulted through:

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<sup>1</sup> COM(2011) 5 final. Report from the Commission to the European Parliament and the Council. Mid-term review of the European satellite radio navigation programmes. See Annex A for an overview of the Report.

<sup>2</sup> Full list of Commission directorates-general and services abbreviations: <http://publications.europa.eu/code/en/en-390600.htm>

- The Eurobarometer survey in June 2007<sup>3</sup> which questioned around 26 000 citizens all over the European Union on a range of issues linked to Galileo and satellite positioning systems in general;
- The Eurobarometer survey in July 2009<sup>4</sup> which questioned around 25 000 citizens in the European Union on space activities, including the importance of developing an independent positioning system in Europe;
- A public consultation on a possible EU Space Programme in January - March 2011<sup>5</sup> on space policy, including the importance of impact to major satellite based services.

#### *Key findings*

- The majority of respondents to the two Eurobarometer surveys expressed their **support to continue developing an independent satellite navigation system for Europe** (80% in 2007 and 67% in 2009 of all questioned respondents);
- The **awareness on the increasing reliance on satellite navigation services is growing**, not only within the industry and the academia<sup>6</sup>, but also among general public: 86% of all questioned respondents in the open consultation on possible EU Space Programme is concerned about a disruption/losses in satellite navigation services;
- Industry experts and representatives of public administrations have re-emphasised the **need for stable, long term governance for the European GNSS Programmes**, highlighting a number of changes in the set-up over the past ten years and their negative consequence on the deployment of the programme;
- Concerning technical features of the European GNSS, main feedback aims at **reviewing the Galileo Safety of Life service (SoL) concept**: some key Safety of Life service features such as the limited level of interoperability with other GNSS systems and existing ICAO and Eurocontrol standards<sup>7</sup> are perceived as **hindering a wide adoption by key stakeholders in the civil aviation**. This strong position adopted by this community calls for a redesign of the Galileo SoL concept;
- **EGNOS safety-of-life** service having been declared operational, stakeholders in the civil aviation insist on a **long term stable commitment of the European Union** as the owner responsible for maintaining this infrastructure so as they can engage in investments to adapt aviation infrastructure and processes to the existence of EGNOS.

List of consultation events can be found in the Annex II.

#### *External expertise*

This impact assessment is also based on a number of external studies and articles (a complete list can be found in Annex III). It builds primarily on the position papers on requirements for satellite navigation systems from user communities<sup>8</sup>, the 'Exploitation study' assessing the

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<sup>3</sup>Flash Eurobarometer 211/2007: <http://www.gsa.europa.eu/index.cfm?objectid=6BA4CAC6-A37E-B230-87DB16533E07D8D7>

<sup>4</sup>Flash Eurobarometer 272/2009: [http://ec.europa.eu/public\\_opinion/flash/fl\\_272\\_en.pdf](http://ec.europa.eu/public_opinion/flash/fl_272_en.pdf)

<sup>5</sup>Public consultation on a possible EU Space Programme: [http://ec.europa.eu/enterprise/policies/space/esp/public-consultation/index\\_en.htm](http://ec.europa.eu/enterprise/policies/space/esp/public-consultation/index_en.htm)

<sup>6</sup>Global Navigation Space Systems: reliance and vulnerabilities (2010), UK Royal Academy of Engineering

<sup>7</sup>Eurocontrol Policy on GNSS for Navigation Applications in the Civil Aviation Domain, SCG/8/AP10, 28.04.2008

<sup>8</sup>Position papers from the user communities (2009, 2010): International Civil Aviation Organisation (ICAO), the European Organisation for the Safety of Air Navigation (Eurocontrol) and COSPAS-SARSAT an

future evolution of the European GNSS programmes after 2013<sup>9</sup> and a number of studies and articles on dependency on GPS<sup>10</sup>.

### *Ex-post evaluations*

This impact assessment also builds on the two successive evaluations: firstly, on the assessment of the Galileo programme's development phase until 2008 carried out by the Court of Auditors<sup>11</sup> and secondly, on the evaluation of both the Galileo and EGNOS programmes since 2008, when the Commission took over as programme manager, i.e. the mid-term review of the European Satellite radio navigation programmes.<sup>12</sup> The results of those evaluations, their recommendations and the way they were taken forward are described in section 3.2.

### *Other related impact assessments*

In 2010, the Commission published an impact assessment which accompanied the Action Plan on global navigation satellite system applications. It focused on assessing the impact of different EU actions to support the increase of satellite navigation downstream applications for users.<sup>13</sup>

A separate impact assessment on the liability issues will be carried out by the European Commission by the end of 2011 to assess different liability regimes linked to the exploitation of the European GNSS programmes. This impact assessment will build on the present one as it will depend on the chosen governance scheme.

## **1.4. Scrutiny by the Commission Impact Assessment Board**

The Impact Assessment Board of the European Commission assessed a draft version of the present impact assessment and issued its opinion on 2<sup>nd</sup> September 2011. The Impact Assessment Board made several recommendations in strengthening the link between the objectives and problem drivers, making better use of the evaluation findings, demonstrating better the EU added value, better explaining the scope of the options and improving the description of the methodologies used for assessing the impacts.

In the light of the latter, the final impact assessment report:

The report takes those recommendations on board by improving the intervention logic between objectives and problem drivers in chapters 3 and 4, by improving the description of the EU-added value in chapter 2.1, by explaining the scope of the options in chapter 5 and improving Annex VI on methodologies used.

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intergovernmental organisation for search and rescue, primarily on the requirements and expectations of users on the quality of services

<sup>9</sup> Exploitation Study (2009), Roland Berger Strategy Consultants, commissioned by the European Commission

<sup>10</sup> See list in Annex III.

<sup>11</sup> Court of Auditors special report 7/2009. This report contains a clear overview of the governance and financing flow of the Galileo and EGNOS programmes during 1999-2007.

<sup>12</sup> COM(2011) 5 final of 18.1.2011 on Mid-term review of the European Satellite radio navigation programmes

<sup>13</sup> COM/2010/0308 final of 14. 6. 2010. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - Action Plan on Global Navigation Satellite System (GNSS) Applications SEC(2010)717 SEC(2010)717

## 2. CONTEXT

### 2.1. Europe needs a global navigation system: rationale and added value

#### *Rationale*

Knowledge of highly reliable and accurate information on position, velocity and time is fundamental to improving efficiency in many areas of our economy and daily lives. The experience of the US GPS (Global Positioning System) has demonstrated the advantages of satellite navigation to the extent that it is regarded in the USA as the fifth utility<sup>14</sup>, alongside water, electricity, gas and telephone. The US military and civil users have developed a considerable dependence on the GPS. The military are reliant, to a significant extent, on satellite navigation as an aid to effective command and control. Civil applications are steadily increasing, especially for personal use in vehicles and mobile phones, and many utility networks for telecommunications or energy are also more and more relying on the precise time synchronisation provided by the satellite navigation systems.

As the **use of and the dependence on satellite navigation spreads**<sup>15</sup>, the prospect to revert to traditional positioning and timing methods becomes more and more difficult. The implications<sup>16</sup> of a disruption of satellite navigation services are even greater, jeopardising not only the efficient running of transport but also human safety<sup>17</sup>.

Several countries have become aware of their dependence and are now building their own **Global Navigation Satellite System (GNSS)**. With the launch of the first Chinese COMPASS satellite in 2007, the fourth global competitor in the GNSS market emerged after US GPS, Russian GLONASS (Global'naya Navigatsionnaya Sputnikovaya Sistema) and the European Galileo programme. The Chinese COMPASS is expected to be completed between 2015 and 2020<sup>18</sup>. At the same time regional systems<sup>19</sup> are developed by India and by Japan.

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<sup>14</sup> The White House, Office of the press secretary. Press briefing by Assistant Secretary of Transportation, Gene Conti, 1 May 2000

<sup>15</sup> Exploitation Study (2009)

- Personal Navigation Device (PND) penetration rate in cars was 0% before 2000, reached 36% in 2011 and should reach 80% by 2015. In vehicle PND penetration rate was 0% before 2000, reached 10% in 2011 and will continue to growth to 50% by 2025 (Source Gartner, LEK)
- Mobile devices sales to end users are expected to reach 1,7 billion by 2011 worldwide. Smartphones are expected to represent 1/3 of mobile devices sales in 2011. GNSS penetration rate in 2020 is around 24% and would climb to 50 à 65% in 2020 of overall mobile phone sales (Source Gartner, LEK)

<sup>16</sup> Global Navigation Space Systems: reliance and vulnerabilities (2010), UK Royal Academy of Engineering, [http://www.raeng.org.uk/news/publications/list/reports/Global\\_Navigation\\_Systems.pdf](http://www.raeng.org.uk/news/publications/list/reports/Global_Navigation_Systems.pdf)

<sup>17</sup> Why Europe needs Galileo, 2010, European Space Agency

<sup>18</sup> "The less known, but crucial elements of the European Space Flagship Programmes: Public Perception and International Aspects of Galileo/EGNOS and GMES", European Space Policy Institute, Report 34, May 2011

<sup>19</sup> Regional systems provide additional signals from satellites operating over a given geographical area that are compatible with one or more GNSS systems. Regional satellite positioning systems proposed or under development include: **The Indian Regional Navigation Satellite System (IRNSS)** will include three satellites in geostationary orbit and four satellites in geosynchronous orbit, transmitting L-band and S-band signals and providing coverage primarily for the Indian land mass. The first satellite is planned for launch in mid-2009 and a complete constellation currently scheduled to be in place by 2011. **The QZSS, the Quasi-Zenith Satellite System (Japan)** proposes three inclined geosynchronous orbit (IGSO) satellites operating over Japan and surrounding areas and transmitting signals that are compatible and interoperable with existing and future modernized GPS signals. First launch is not expected late in 2010 (source: Inside GNSS <http://www.insidegnss.com/aboutregional>)

Nowadays satellite navigation users in **Europe have no alternative than to use the satellite signals from the US GPS or GLONASS** for positioning and navigation. The European dependence on the satellite radio navigation provided by the GPS is estimated to represent 6% to 7% of the GDP of EU-27, i.e. € 800 billion in the European Union.<sup>20</sup> Yet the military operators of these systems can give no guarantee to maintain an uninterrupted service. Consequently, the European economy is increasingly relying on a military infrastructure not controlled by Europe and not primarily designed to serve European economic purposes. Furthermore, these systems experience a poor availability particularly in densely populated urban areas<sup>21</sup>. Also, they do not provide sufficient guarantee for quality and continuity of service to European civilian users.

### *Political objectives*

With GPS being fully operational in the early 1990s, the European Union saw the need for Europe to have its own global satellite navigation system<sup>22</sup>. Long before the wide dissemination of the Personal Navigation Devices (PNDs), the Council and Parliament have foreseen an increased need for navigation. **The European independence in satellite navigation was the primary driver behind this endeavour.** This political objective had the following goals:

- To set up a first global satellite navigation system completely **independent of other existing systems** under **civilian control**, which would guarantee uninterrupted GNSS services and a strategic advantage for Europe. However, as became clear later, interoperability with other systems, in particular with the US GPS, would need to be pursued;<sup>23</sup>
- To reinforce the resilience of the European economic infrastructure by providing a **backup system in case of signal failure** from other systems;
- **To maximise socio-economic benefits** for European civil society relying on more accurate, available and robust signal by exploiting the new opportunities generated by high-precision satellite navigation to a much fuller extent than currently possible;
- **To demonstrate Europe's ability to develop**, deploy and operate complex **large-scale space infrastructures**.

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<sup>20</sup> COM(2010)308 of 14.6.2010, Impact assessment, accompanying document to the Communication of the European Commission on Action Plan on Global Navigation Satellite System (GNSS) Applications. The size of economical activities that rely on GNSS is conservatively estimated as 6-7% of the whole GDP of the European Union (ca €800 bn), which highlights the intrinsic value of GNSS for the economy and, therefore, the importance of securing its supply. The estimation is based on a number of US studies assessing the reliance of various industry sectors on GNSS technology, in particular a study elaborated by the George Washington University which measured their combined contribution to USA GDP as a total of \$1342 bn, which represent around 9.5% of USA GDP in 2009. A similar calculation was carried out for the EU-27 region, based on a contribution of various industries impacted by GNSS to the GDP, which resulted in the impact potential of 6-7% of EU GDP.

<sup>21</sup> Study into the impact on capability of UK commercial and domestic services resulting from the loss of GPS signals (2001): <http://www.ofcom.org.uk/static/archive/ra/topics/research/topics/other/gpsreport/gps-report.pdf>

<sup>22</sup> Council Resolution on the European contribution to the development of a Global Navigation Satellite System (GNSS) of 19 December 1994

<sup>23</sup> International Agreement of June 2004 on the promotion, provision and use of Galileo and GPS satellite-based navigation systems and related applications

### *Added value*

The added value of the European GNSS lies not only in ensuring Europe's independence with regard to a critical technology but also in securing important macro-economic benefits for the European Union, catalysing the development of new services and products based on GNSS and generating technological spin-offs beneficial for research, development and innovation<sup>24</sup>.

**The European satellite navigation policy**<sup>25</sup> is based on these goals and aims at providing the EU with two satellite navigation systems, established under EGNOS and Galileo programmes:

- The first satellite navigation system, **the European Geostationary Navigation Overlay Service (EGNOS)**, is a **satellite based augmentation system**<sup>26</sup> that transmits information on the reliability and accuracy of the positioning signals sent out by US GPS or Galileo in the future. The added value of EGNOS lies in improving the signals and making them suitable for safety critical applications such as Aviation and Maritime navigation services, over the European area<sup>27</sup>.
- The second satellite navigation system established under the **Galileo** programme, will be the first global satellite navigation and positioning infrastructure specifically designed for **civilian purposes independent** from other existing or potential systems.

In comparison to the existing US GPS system today, the users of Galileo system will have:

1. **Better precision in navigation:** In a combined GPS-Galileo use (compared to GPS by itself) the higher number of satellites available to the user will offer higher precision. From most locations, six to eight Galileo satellites will be visible which, in combination with GPS signals, will allow positions to be determined up to within a few centimetres.

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<sup>24</sup> A detailed analysis was presented in the Commission Communication on the status quo of the Galileo and EGNOS programmes published in 2007 (COM(2007)261 final and COM(2007)534/2).

<sup>25</sup> Defined in the GNSS Regulation

<sup>26</sup> Augmentation systems are designed to improve one or more qualities of a GNSS system or systems, such as accuracy, robustness, and signal availability. Satellite-based augmentation systems (SBAS) augment core satellite constellations by providing ranging, integrity and correction information, which increase accuracy, reliability, and availability of GNSS positioning. SBAS information is broadcast via transponders on geostationary satellites in the same band as the core constellations. The elements of an SBAS system typically include a network of ground reference stations that monitor satellite signals; master stations processing reference stations data and generating SBAS signals, and uplink stations to that transmit the messages to the geostationary satellites. Several commercial SBAS systems are providing services to users, including OmniSTAR (Fugro, The Netherlands), Starfire (NavCom Technology, United States), and Veripos (Subsea 7, United Kingdom). There are four non-commercial SBAS: Wide Area Augmentation System (WAAS), USA, European Geostationary Navigation Overlay Service (EGNOS), Europe, GPS Aided GEO Augmented Navigation (GAGAN), India, MTSAT (Multi-functional Transport Satellite) Satellite Based Augmentation System (MSAS), Japan (source: Inside GNSS, <http://www.insidegnss.com/aboutregional>).

<sup>27</sup> The European area for the EGNOS system is the area of 44 members states of the European Civil Aviation Conference.

2. Better availability of the signals: The high number of satellites will also improve the availability of the signals in high-rise cities, where buildings can obstruct signals from satellites that are low on the horizon.

3. Better coverage by the signals: Galileo will also provide a better coverage at high latitudes than GPS, thanks to the location and inclination of the satellites. This will be particularly interesting for Northern Europe.

The independence of the Galileo system needs to be underlined as it is the main political objective in setting up this system (for a technical details see chapter 6.1.1.1). However, interoperability of this system with other existing or future satellite navigation systems and in particular with the US GPS is an important added value. Once Galileo is operational, the market users will take advantage of the interoperability and multiplication of the satellite navigation systems with increased reliability and precision, and most receivers will operate using data from several systems. Moreover, users need back-up systems in case of system failure or voluntary interruption of signals, hence the value added of a civilian system.

#### *Political position on the European GNSS*

Both EGNOS and Galileo have constantly been reaffirmed as key programmes for Europe by the Council of the European Union and the European Parliament over the past ten years<sup>28</sup>.

In March 2011 the Council adopted its Conclusions on the Mid-term review<sup>29</sup> in which it:

- *"Underlines that the European satellite navigation systems are of strategic importance for the independence of the European Union regarding satellite navigation, positioning and timing services [...];*
- *Stresses that, as EU flagship programmes in space, EGNOS and Galileo would allow the development of a strong and innovative downstream application market in Europe and will significantly contribute to the economic recovery of Europe [...];*
- *Reaffirms its strong commitment in favour of the European satellite navigation programmes (EGNOS and Galileo), emphasizes the need for a timely deployment of a competitive and independent Galileo constellation and acknowledges the substantial economic and social benefits for the European Union and its citizens"*

On 8 June 2011, the European Parliament adopted an own-initiative report<sup>30</sup> in response to the mid-term review of the GNSS programmes<sup>31</sup> in which it:

- *"Emphasises the strategic importance of space policy and the GNSS programme in the drive to establish a genuine European industrial policy based on practical projects with tangible benefits for the public and for business[...];*
- *Points out that long-term stability is important in order to minimise additional delays, costly redesign and destabilisation of the user base [...];*

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<sup>28</sup> See Annex V, section on Council resolutions and decisions and Parliament resolutions

<sup>29</sup> Council Conclusion of 31 March 2011 on the Report from the Commission to the European Parliament and the Council Mid-term review of the European satellite radio navigation programmes

<sup>30</sup> INI/2009/2226, Report on the mid-term review of the European satellite navigation programmes: implementation assessment, future challenges and financing perspectives. Committee on Industry, Research and Energy. Rapporteur: Vladimír Remek.  
<http://www.europarl.europa.eu/oeil/FindByProcnum.do?lang=en&procnum=INI/2009/2226>

<sup>31</sup> Idem footnote 12

- *Considers that Galileo and EGNOS, as European programmes owned by the EU which address a public interest at EU level, should mainly be financed through the EU budget; believes that – alongside the contribution from the EU budget – all possible sources of financing should be investigated, including innovative forms of financing [...];*
- *Believes that the long-term governance and management structure of GNSS should address the division of tasks and responsibilities between the Commission, the GSA and the European Space Agency, as well as other relevant issues, such as appropriate cost-sharing, the revenue-sharing mechanism, the liability regime, pricing policy and the possible involvement and contribution of the private sector in the GNSS programmes [...];”*

More information on related EU policies can be found in section 4.4.

## **2.2. Governance, financing and legal framework**

### *Origins of Galileo and EGNOS*

In 1999 the Council called on the Commission to develop a global system managed by public civil authorities<sup>32</sup>, and in 2001 the Council approved to launch the European satellite navigation programme Galileo<sup>33</sup>. The Council decided that the deployment and exploitation phases of Galileo would be based on a Public-Private-Partnership whereby the EU would pay for a third of the cost of the system. In 2002 a dedicated organisational structure, the Galileo Joint Undertaking (GJU), was set up by the Commission and the European Space Agency (ESA) to create a common management and funding platform for the Galileo programme. The Galileo Joint Undertaking carried out concession negotiations with a consortium of private companies to establish a Public-Private Partnership. These negotiations did not succeed in 2007 as a result of unwillingness of the private sector to accept the most important programme risks, namely design and market-related risks.<sup>34</sup> By the end of 2006, the European GNSS Supervisory Authority<sup>35</sup> (GSA), replacing the GJU, had been set up to manage the public interest aspects of the European GNSS programmes. The European Space Agency carried the responsibility over the management and implementation of the GNSS programmes, with a combined funding of the EU and ESA of € 2.8 bn.

In November 2007 the Council reached conclusions on the future development of Galileo, specifically on the governance and procurement aspects. It was agreed that the public governance of the programmes should be based on the principle of a strict division of responsibilities between the European Union, represented by the Commission, the GSA and the ESA.

In the meantime, EGNOS was developed under joint effort by the European Commission, Eurocontrol and ESA between 1995 and 2007 with the support of the European industries gathered in the EGNOS Operator and Infrastructure Group (EOIG).

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<sup>32</sup> Council Resolution of 19 July 1999 on the involvement of Europe in a new generation of satellite navigation services - Galileo-Definition phase, OJ C221 of 3.8.1999

<sup>33</sup> Council Resolution of 5 April 2001 on Galileo, OJ C175 of 30. 5. 2001

<sup>34</sup> As the Court of Auditors concluded in its report (Court of Auditors special report 7/2009), the management of the Galileo programme's development phase (until 2008) was inadequate: the Galileo Joint Undertaking was not a strong programme manager, it did not achieve most of its objectives, the programme lacked a strong strategic sponsor and supervisor, and the Member States given their different expectations intervened mostly in the interest of their national industries.

<sup>35</sup> Regulation (EC) 1321/2004



In 2008 the **Regulation (EC) No 683/2008 on further implementation of the Galileo and EGNOS programmes (GNSS Regulation)** was adopted. It entrusted the Commission the responsibility for managing the Galileo and EGNOS programmes with full EU funding. The Commission signed a delegation agreement with the ESA in 2008 on the further implementation of Galileo assigning the role of a Design and Procurement Agent to ESA. For the EGNOS programme, in 2009 the Commission signed a contract with a consortium European Satellite Services Provider (ESSP-SAS) to manage operations and maintenance of the EGNOS system. Given the role of the European Commission under the new governance scheme, the need for a separate authority to manage the public interest disappeared. This led to the re-profiling of the role of the GSA towards mainly the security domain and the preparation of the market entry of EGNOS and Galileo.

With the GNSS Regulation the **European Union became the sole political body in charge of setting the European GNSS policy**. The Commission, acting on behalf of the EU, prepares and submits to Council and Parliament strategic orientations to be pursued, prepares on behalf of the EU functional requirements, proposes budget of the programmes to the budget authority and executes accordingly all the activities required to manage the programmes. It is however to be noted that the governance of system security issues departs from this general scheme, as Council and Member States are directly involved in the security related decision making process.

The specificity and the novelty of this set-up need to be underlined: it is the first time that the **European Union is fully responsible for and owns any large scale infrastructure**, notably a space system<sup>36</sup>. As such, the European GNSS are the first tangible building blocks of a European Space policy.

The GNSS Regulation sets out the EU funding to both Galileo and EGNOS programmes for 2007-2013 which amounts to € 3.4 billion. This budget has been split across the three main activities, namely completion of the Galileo development phase (accounting for around € 600 million), the Galileo deployment phase (€ 2.4 billion) and the operation of EGNOS (around € 400 million).

The GNSS Regulation also defines the objectives of the Galileo and EGNOS programmes, their respective infrastructure and their development phases as outlined in the following sections.

#### *EU Budget proposal: multiannual financial framework 2014-2020*

The Commission adopted an over-arching proposal for the next multiannual financial framework for the EU Budget 2014-2020<sup>37</sup> on 29 June 2011. This proposal states that the European GNSS programmes will continue to be financed fully from the EU budget. The analysis of other sources of financing was done in the Commission Staff working paper accompanying the budget proposal<sup>38</sup>. It is proposed that the ceiling for the European satellite navigation programmes from the EU budget for the period 2014-2020 is EUR 7 000 million.

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<sup>36</sup> For example, in the case of the Global Monitoring for Environment and Security programme (GMES), the system consists of Member States and EU assets, not requiring a centralised decision making body.

<sup>37</sup> COM(2011) 500 of 29.6.2011 "A Budget for Europe 2020"

<sup>38</sup> SEC(2011) 868 of 29.6.2011 Commission Staff working paper: A Budget for Europe 2020: the current system of funding, the challenges ahead, the results of stakeholders consultation and different options on the

### 2.2.1. Galileo: Objectives, infrastructure and implementation phases

The objective of the Galileo programme, as referred to in the GNSS Regulation, is to offer five services with distinct characteristics:

- **the Open Service (OS)**, for mass-market applications, will provide freely accessible signals for timing and positioning;
- **the Safety-of-Life service (SoL)** for increasing safety and efficiency in air and maritime transport, will improve the OS performance through the guaranteed provision of timely warnings when certain margins of accuracy are not met (signal integrity messages);
- **the Commercial Service (CS)**, for market applications requiring higher performance and robustness than offered by the OS, will provide encrypted protected signals for protection of added value services (on payment of a fee);
- **the Public Regulated Service (PRS)**, for a robust and access-controlled service for government applications, will be operational at all times and in all circumstances and uses robust encrypted signals, which protects it against interference or disruptions;
- **the Search and Rescue service (SAR)**, for the international cooperative effort on the humanitarian search and rescue, defined in cooperation with the International Satellite System for Search and Rescue organisation (COSPAS-SARSAT), will allow several important improvements in the existing system, e.g. near real-time reception of distress messages and very precise location of alerts.

To define these services, the Commission, with the support of ESA, drew up the **Galileo Mission Requirements Document (MRD)**<sup>39</sup>, based on extensive iterative consultation with end-user communities<sup>40</sup>. The Galileo MRD provides details on each service, their implementation, verification and operational requirements to be delivered by the Galileo Satellite Navigation System. This document is consistent with the Galileo Mission High Level Definition document (HLD)<sup>41</sup> which presents the main characteristics of the Galileo programme and describes the services and performances offered by the Galileo system.

In order to deliver the five services, Galileo will consist of the following **infrastructure**:

- **Space infrastructure** consisting of a constellation of 30 satellites in medium earth orbit, 27 operational satellites and 3 spares, to emit signals needed for provision of services,
- **Ground infrastructure** consisting of the ground control segment for the operations and control of the satellite constellation and a ground mission segment for the processing of data delivered from a set of globally distributed sensor stations and the generation of the navigation messages.

Building up the infrastructure and provision of services is divided into **three phases**<sup>42</sup>:

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main horizontal and sectoral issues. Accompanying the document to the Communication from the Commission A Budget for Europe 2020 COM(2011) 500 of 29.6.2011

<sup>39</sup> The Galileo MRD is an internal Commission document.

<sup>40</sup> Galileo Justification for Mission Requirements Document, an internal Commission document.

<sup>41</sup> [http://ec.europa.eu/dgs/energy\\_transport/galileo/doc/galileo\\_hld\\_v3\\_23\\_09\\_02.pdf](http://ec.europa.eu/dgs/energy_transport/galileo/doc/galileo_hld_v3_23_09_02.pdf)

<sup>42</sup> Art (3) Regulation (EC) No 683/2008 of the European Parliament and of the Council of 9 July 2008 on the further implementation of the European satellite navigation programmes

- **The development phase**, aiming at reaching In Orbit Validation (IOV) of the system: construction and launching of the first four satellites and construction of the first ground-based infrastructures, allowing to develop, validate and verify the Galileo system before its deployment;
- **The deployment phase**, aiming at reaching two successive steps:
  - Initial Operational Capability (IOC) of the system: extension of the infrastructure to eighteen satellites and upgrading the ground segment allowing provision of early services for OS, PRS and SAR;
  - Full Operational Capability (FOC): completion of the infrastructure and full provision of five services;
- **The exploitation phase**, set to begin at the latest upon conclusion of the deployment phase: involves service provision, management and operation of the infrastructure, the maintenance, constant improvement and renewal of the system.

### 2.2.2. EGNOS: Objectives, infrastructure and implementation phases

The EGNOS programme, which complements the signals of the US GPS to provide users with a more precise positioning over the European area<sup>43</sup>, is to provide **three services**:

- **the Open Service (OS)**: for mass-market receivers and common user applications. It provides freely accessible signals for positioning, it was declared operational<sup>44</sup> in October 2009 and is already used in several activities such as agriculture;
- **the Safety-of-Life service (SoL)**: for safety-critical transport applications, namely in civil aviation. It provides enhanced and guaranteed performance and features an integrity warning system. It was declared operational in March 2011 and is used by aviation and maritime transport sectors in Europe;
- **the EGNOS Data Access Service (EDAS)**, for enhanced applications, it provides terrestrial commercial data service and is offered on a controlled access basis (e.g. through Internet or mobile phones), possibly on payment of a fee in the future.

The Commission, with the support of ESA, drafted the **EGNOS System Mission Requirements Document**<sup>45</sup>, in order to detail these services. The EGNOS MRD defines the high-level mission requirements applicable to EGNOS system, services and operations.

To be able to deliver these three services, the **infrastructure** of EGNOS consists of:

- **Space infrastructure** of three geostationary (GEO) satellites,
- **Ground infrastructure** consisting of 34 ranging and integrity monitoring stations (RIMS) mainly in Europe, 4 control and processing centres to process the RIMS data, to generate corrections for the navigation data and to provide information on the integrity of the system, and 6 navigation land earth stations to upload the correction data to GEO satellites;

The development and deployment of **EGNOS have been completed**, the exploitation started **in October 2009**.

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<sup>43</sup> Idem footnote 27

<sup>44</sup> EGNOS Service Definition Document - Open Service:

[http://ec.europa.eu/enterprise/policies/satnav/egnos/files/brochures-leaflets/egnos-os-sdd\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/brochures-leaflets/egnos-os-sdd_en.pdf)

<sup>45</sup> The EGNOS MRD is an internal Commission document.

### 3. PROBLEM DEFINITION

#### 3.1. Challenges

Today, the implementation of the GNSS Programmes raises many challenges for the European Union. As highlighted in section 2.2 it is the **first time** the EU owns and is fully in charge of programmes of such **magnitude** and **technical complexity** on a very **long time-span**.

- **First time:** the European Union does not have experience in managing similar programmes with such particular security requirements and such level of technical details;
- **Magnitude and technical complexity:** these programmes are not based on off-the-shelf technology but on the technology specifically developed for a concrete purpose, requiring heavy upfront investment and continuous maintenance and technological updates of the design;
- **Long-term commitment:** building space systems requires a long-term commitment and adequate funding to support the implementation and exploitation. The time-scale of building such space programmes is 20 years, comparable to the development of the US GPS or any design in the aerospace sector while this may not be in line with the EU budgetary cycle;
- **Short-term window of opportunity:** To maximise economic benefits expected from the Galileo system, the timing is crucial - Galileo needs to be the second global satellite navigation system of reference to ensure the penetration of the Galileo standards in the industry. This window of opportunity is narrow as other competing Russian (GLONASS) and Chinese (COMPASS) GNSS are building up progressively their full operational capability.

Should these challenges not be tackled appropriately, the EU would fail to successfully deliver the economic and social benefits expected from the European GNSS Programmes.

#### 3.2. Evaluations of the GNSS programmes

The **Court of Auditors** published a report<sup>46</sup> in 2009 on the management of the Galileo programme's development phase (until 2008). The Court concluded on a number of recommendations that were taken up by the Commission in the new governance design and which aimed at supporting the Commission in its task of programme manager as of the adoption of the GNSS Regulation July 2008.

In January 2011 the Commission published a Communication<sup>47</sup> on the **mid-term review of the European satellite radio navigation programmes** (summary attached in Annex I). The mid-term review evaluates ex-post the programmes since 2008 when the Commission took over as programme manager and concludes that significant progress has been made: EGNOS system is operational and the Galileo ground installations are ready for the launch of the first operational satellites in 2011. The report clearly identifies the main problems:

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<sup>46</sup> Court of Auditors special report 7/2009. This report contains a clear overview of the governance and financing flow of the Galileo and EGNOS programmes during 1999-2007.

<sup>47</sup> COM(2011) 5 final of 18.1.2011 on Mid-term review of the European Satellite radio navigation programmes

- Cost overruns resulting in a need for additional resources to complete the Galileo infrastructure and delays in delivering this infrastructure
- Undefined funding and governance for the exploitation phase of both programmes which could compromise the objectives of the GNSS Regulation.

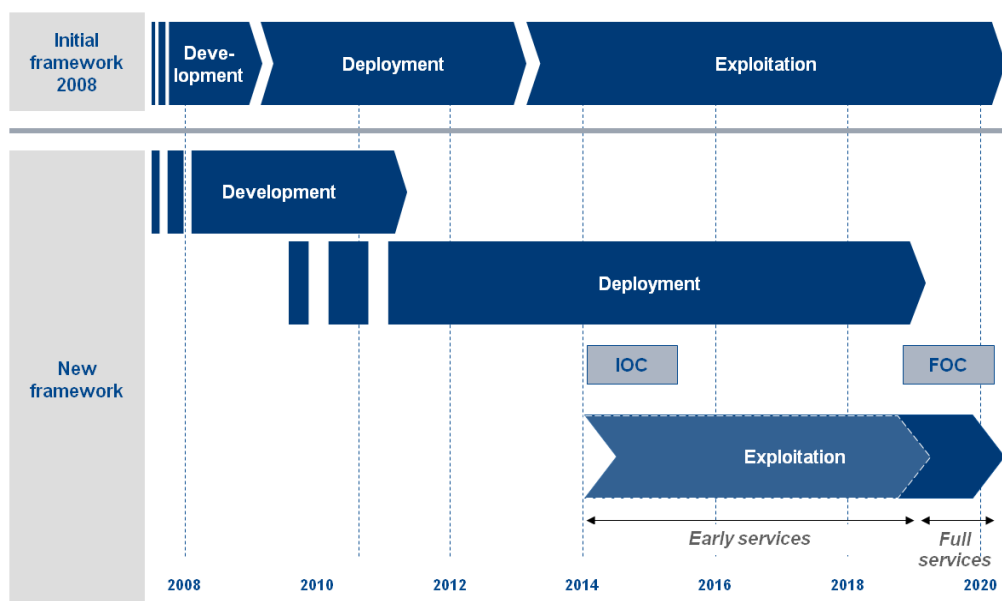
These problems and their drivers are described in more detail in the following two chapters. Recommendations for improvement include in short-term a need to provide the first Galileo services in 2014-2015 and in a long-term the need to complete the Galileo infrastructure and secure related financing and governance. They are reflected in the design of policy options.

### 3.2.1. Galileo

The Galileo programme is facing cost overruns for financing the system infrastructure and delays in delivering this infrastructure. In 2008 the GNSS Regulation set a schedule according to which the development phase would be completed by 2009, the deployment of the infrastructure by 2013 and the exploitation phase would start as of 2014-2015.

The development phase suffered a delay of three years and is now expected to be completed in 2012. Consequently, the deployment phase is expected to reach initial operational capacity (IOC) and provide early services in 2014-2015 and full operational capacity (FOC) in 2019 as outlined below in Figure 1.

**Figure 1: Overall schedule of the implementation of the Galileo programme**



- The **Development and Validation Phase** started in 2002 and should have originally run until 2005. Two experimental satellites (GIOVE-A, GIOVE-B) were launched which fulfilled the primary task of bringing into use the frequency filings according to the provisions of the International Telecommunications Union (ITU) Radio Regulations (RR). In-Orbit Validation is using four fully-fledged satellites that are expected to be launched between 2011 and 2012.
- The **Deployment Phase** which comprises the building up of the full Galileo system by launching the complete constellation of 30 satellites, including 3 in-space spares, and building up the ground structure is expected to deliver first services as of 2014-2015 (IOC) and to reach full operational capability (FOC) in 2019.

- The **Exploitation Phase**, operation of the system, will start in parallel with the deployment phase to provide early services and fully after the completion of Full Operational Capability.

The fact that the Galileo programme will not deliver as planned was caused by a number of difficulties (i.e. drivers) listed below. They generated delays and additional costs mainly related to technical risks and security constraints.

In the **development phase**, several difficulties<sup>48</sup> were encountered:

- The transfer of project supervision meant the need to renegotiate some contracts and the requirements associated with putting the new arrangements in place;<sup>49</sup>
- An unforeseen second experimental satellite was launched in order to retain the frequencies that were filed to the ITU;
- Technical constraints were related to the finalisation of certain security-related aspects (e.g. necessity to deploy ground stations only on the European territories and not worldwide as was initially planned);
- Unexpected delays were associated with setting up contracts for the deployment phase;
- A number of technical risks, stemming from the technical complexity of the programme and the lack of previous experience in similar projects, needed to be validated during the in-orbit validation phase. They were not accounted for in the initial planning and generated further delays and costs.

All those difficulties generated cost overruns amounting to EUR 560 million for the ESA development phase. At the request of Member States, the Commission agreed to bear this cost so as to ensure the continuity of the programme despite the fact that this cost should have been financed directly from the national budgets of the ESA members. This cost was unforeseen and had to be covered from the budget of 3.4 billion EUR initially planned for the deployment phase.

The **deployment phase** recorded further delays and cost overruns:

- An increase in prices for launch services worldwide led to an extra cost of some EUR 500 million for the deployment phase;
- A lack of competitive bids due to monopoly situation of some tenderers, led to increased prices;
- The higher costs of satellites, launchers and ground segment, led to the increase of the system cost exceeding the 2007/2008 preliminary estimates.

The Commission took steps to reduce the impact of these problems and proposed a number of measures to reduce their impact, including:

- Providing more accurate estimations of expected procurement costs: unlike in 2007, the Commission today has access to real market prices for most of the services it requires to complete and operate the Galileo and EGNOS infrastructures. Contracts are in place that provide for price stability for some time to come.
- Achieving greater clarity on the technical requirements and the ability of industry to deliver: In particular as regards the Safety-of-Life service, discussions with Member States and user communities have greatly progressed, to the point that implementation options are better known today.

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<sup>48</sup> COM(2011) 5 final of 18.1.2011 on Mid-term review of the European Satellite radio navigation programmes

<sup>49</sup> For details on transfer of project supervision, see Court of Auditors Special report 7/2009

- More realistically assessing the various risk factors that can affect the programmes as previous cost estimations for the GNSS programmes were not based on an appropriate risk assessment.

The ultimate objectives of the Galileo programme have not been called in question. However, due to the described delays and cost overruns, the 2007-2013 budget for the European GNSS programmes allowed for building only 14 satellites (out of the 30 envisaged) to be launched as of 2012. They will add to the four IOV satellites to form the constellation of 18 satellites. A first version of the ground infrastructure will also be deployed. Based on this infrastructure, early services will be provided from 2014-2015 but only in cooperation with the US GPS.

More recently, the Vice-President of the Commission Antonio Tajani announced<sup>50</sup> further potential savings through rationalising costs and putting pressure on industry for an improved deal.

It needs to be emphasised that the problem drivers cannot be completely tackled as existence of uncertainties and risk in programme management is an inherent feature of complex programme. Therefore, despite various mitigation measures can be taken, it would be inappropriate to suggest that these will eliminate the drivers completely.

### 3.2.2. EGNOS

The EGNOS programme will deliver as planned. The Open Service officially became operational on 1 October 2009. The system has operated since then in accordance with the required specifications. The Safety of Life service was declared open on 2<sup>nd</sup> March 2011. The third service for dissemination of commercial data EDAS should be provided as of 2012.

### 3.3. The problem that requires action

Given the delays and cost overruns described in the previous section, the system developed under the **Galileo programme** will not be fully operational by 2013 as planned and it will not be completed within the budget allocated in the current multi-annual financial framework as stated in the GNSS Regulation.

As regards the **EGNOS programme**, by the end of 2013, the system will provide all services as stated in the GNSS Regulation. However, the operations, maintenance and evolution of the system need to be secured.

Therefore, the present report will investigate the **way forward for both programmes given the two identified problems:**

1. **The Galileo system will not be fully operational and will not independently provide all five services in 2013 as planned.**

Since its development phase, the Galileo programme encountered cost overruns and delays in delivering a system as summarised in the evaluations of the Galileo programme. The effects of these problems were partly prevented by a number of mitigation measures as described in chapter 3.2. However, the schedule set by the GNSS Regulation according to which the Galileo system is fully operational and provides independently all five services (see chapter 2.2.1) by 2013 cannot be met.

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<sup>50</sup> Press conference on 22.6.2011, Paris Air Show, France.

Therefore, the first problem will address what are the options for deploying the Galileo system after 2013 in terms of services and infrastructure, while any option considered will need to ensure the on-target cost and on-target date delivery of the Galileo services, anticipating to the best any further drift.

## **2. The financing and governance framework for the exploitation phase of both Galileo and EGNOS programmes after 2013 is not yet established.**

Following the adoption of the Commission's proposal for the next multiannual financing framework (2014-2020)<sup>51</sup>, it is proposed that the Galileo and EGNOS programmes are fully financed from the EU budget.

As the GNSS Regulation does not lay down the financing and governance framework of the **exploitation phase** for Galileo and EGNOS programmes after 2013, a new legal basis is needed for the systems to be operational, maintained and managed in a long-run. This implies not only a need for financing but also placing new requirements on the operational management of the infrastructure.

As the design and analysis of this new legal and financing framework depends on the options for deployment of the Galileo system, the analysis in this report will be carried out in sequence of the problems.

While the deployment phase of the Galileo programme will be completed in 2018/2019, the exploitation phase will start gradually in 2014. As a result the deployment and exploitation phases will run in parallel for around five years. During this period, the governance of the deployment phase should provide continuity, consistency and credibility towards third parties. Regarding the Galileo exploitation phase, new governance arrangements should be considered and gradually adapt to the needs and experiences arising from the provision of the first services.

As the exploitation phase of the EGNOS programme is ongoing, the long-term governance framework needs to be set-up more urgently as from 2014.

Addressing problem 2 aims at defining **roles and responsibilities** in a **long-term, sustainable and stable** governance framework applicable to the exploitation of **both EGNOS and Galileo**.

It is to be noted that the scope of problem 2 needs to be delimited. The aim of the analysis is neither to decide upon the operational details and timing of the transition between the current and future governance framework nor to decide upon possible intermediary governance for the programmes or to define short-term governance solutions.

### **3.4. Who is affected, in what ways and to what extent?**

The two problems outlined above hamper the provision of services foreseen by the GNSS Regulation: without funding and an appropriate governance framework, the infrastructure available in 2014 will not properly deliver any service.

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<sup>51</sup> COM(2011) 500 of 29.6.2011 "A Budget for Europe 2020"



As outlined in chapter 2.1, this would affect the EU citizens, industry and public authorities at various levels:

- The growth of the European navigation applications industry depends on the very existence of a European GNSS. In the absence of a European GNSS, this whole new sector will fail to emerge;
- Furthermore, several economic sectors rely on the existence of a GNSS:
  - The positioning information it provides, drives transport activities in all its forms and hence logistics systems, that provide goods to EU consumers;
  - The timing information is used to synchronise telecommunications networks and increasingly power management systems, especially in the frame of the development of smart grids.

Of course, these industries do not rely today on a European GNSS and have so far satisfactorily relied on the US GPS. The very fact that US GPS provides a cost-effective solution to positioning and timing needs has accelerated the adoption of GPS based devices in all aspects of EU citizens' daily life. Therefore, the US GPS is seamlessly becoming a single point of failure of EU critical infrastructures, which means that a disruption of GPS signal provision resulting from a technical failure would have a major impact on the European society.

This reliance is not limited to private sector infrastructures and utilities, but is also affecting public authorities and semi-public systems such as: law enforcement, emergency services, land survey applications, monitoring of civil infrastructures, etc.

Finally, the EU, as the owner of tangible and intangible assets already delivered, is also affected as it has the responsibility to preserve investments already made.

### **3.5. Foreseen evolution of the problem**

Should all things stay equal, given the objectives of the GNSS Regulation and the progress on the Galileo programme deployment, the Initial Operation Capacity of the Galileo system will be reached in 2014-2015. The EGNOS system will continue its operations.

The consequences of not having a political decision concerning the financing and governance will impact the further implementation of the Galileo and EGNOS programmes. Without funding and guaranteed exploitation, the operators of Galileo and EGNOS will have to discontinue their activities after mid-2014. This means that the 18 launched satellites of Galileo will gradually move away from their orbits and will be lost some weeks after. The ground infrastructure consisting mainly of electronic equipment that will not be operated or maintained will be unusable after a few months. System suppliers will stop maintaining their technical capabilities in the field of satellite navigation. To sum up, all assets owned by the EU in these programmes which will have cost by then EUR 6.4 billion in total to the EU and ESA will be lost.

The impact will be devastating from the political, economic and scientific point of view. The EU will lose its credibility as a strategic partner in providing global satellite navigation systems vis-à-vis its own citizens, industries and international partners. The economic potential that could have been created by the systems, which is estimated to be around 134 billion EUR over the 2014-2034 period<sup>52</sup> including downstream, upstream market and public

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<sup>52</sup> This amount is detailed in chapter 6.1 Analysis of impacts for problem 1:

benefits, will be lost together with the potential for innovation and building up a high-tech knowledge base in Europe.<sup>53</sup>

From the global perspective, the ambition of the Galileo system will be lost. It will not be the second global satellite navigation system of choice for chip manufacturers. For most receivers two reference constellations are sufficient to ensure adequate service quality. Consequently,, Galileo could definitively loose ground if it arrives only as the third or fourth system. In addition, it will not use the window of opportunity of providing the commercial service to global customers and it will loose out on the potential stimulating effect on the European economy. These opportunities will be taken over by other countries (Russia, China) building their own systems and advancing dynamically as previously mentioned in section 2.1.

### 3.6. EU right to act

The EU right to act is based on article 170 of the Treaty on the functioning of the European Union<sup>54</sup> and the GNSS Regulation on the further implementation of the European satellite navigation programmes (EGNOS and Galileo)<sup>55</sup>.

The establishment of satellite navigation systems cannot be sufficiently achieved by the Member States as it exceeds the financial and technical capacities of any single Member State. Therefore, it can be only achieved by action at EU level.

The GNSS Regulation defines that the European Union shall be the owner of all tangible and intangible assets created or developed under the programmes. As owner of all related tangible and intangible assets, the European Union has to ensure that all conditions to operate and exploit the systems are in place as of the date of introduction of the first positioning, navigation and timing services in 2014-2015. Therefore, the governance is de facto of European nature.

## 4. OBJECTIVES

### 4.1. General policy objectives

The general objective of this proposal as enshrined in the Article 170 of the TFEU<sup>56</sup> "*to contribute to the establishment and development of trans-European networks*" and is further stated in the flagship initiative of the **Europe 2020 strategy**<sup>57</sup>: "*to develop an effective space policy to provide the tools to address some of the key global challenges and in particular to deliver Galileo [...]*". The political objectives as described in chapter 2.1 remain unchanged:

- Set up a first global satellite navigation system (GNSS) under **civilian control** completely **independent of other existing systems**, which would guarantee uninterrupted GNSS services and a strategic advantage for Europe
- Reinforce the resilience of the European economic infrastructure by providing a **backup system in case of signal failure** from other systems

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<sup>53</sup> More details on the impact on the downstream applications market are described in ibid source footnote 13

<sup>54</sup> OJ EU C 83/47 of 30.3.2010

<sup>55</sup> OJ EU L 196/1 of 24.7.2008

<sup>56</sup> OJ EU C 83/124 Official Journal of the European Union 30.3.2010

<sup>57</sup> Communication from the Commission COM(2010)2020 of 3 Mars 2010 on 'Europe 2020 - A strategy for smart, sustainable and inclusive growth', p15

- **Maximise socio-economic benefits** for Europe relying on more accurate, available and robust signal by exploiting the new opportunities generated by high-precision satellite navigation to a much fuller extent than currently possible
- **Build Europe's technical capability** to develop, deploy and operate complex large-scale infrastructures

These political objectives were the basis for defining the European satellite navigation policy in the GNSS Regulation, which aims at providing the EU with two satellite navigation systems established under the EGNOS and Galileo programmes:

- The aim of the Galileo programme is to establish the first global satellite navigation, positioning and timing infrastructure specifically designed for civilian purposes. The system established under the Galileo programme is completely independent of other existing or potential systems and the signals emitted by the system can be used to provide five services as described in chapter 2.2.1.
- The aim of the EGNOS programme is to improve the quality of signals from existing global navigation satellite systems which can be used to provide three services as described in chapter 2.2.2.

#### 4.2. Specific policy objectives

- (1.a) To define a way forward on the further implementation and exploitation of the European GNSS programmes during the next multiannual financial framework 2014-2020 (objectives of the Galileo and the EGNOS programmes are defined in chapters 2.2.1 and 2.2.2 and are used as the baseline for comparison).
- (1.b) To ensure that the policy options for implementation and exploitation of the European GNSS programmes are on-target costs and on-target date delivery.
- (2) To define a long-term, stable, sustainable governance scheme for the exploitation of both Galileo and EGNOS systems that should address and fulfil at best the following objectives:

1. Feasibility	The legal complexity of the initial set-up should be minimised and allow the exploitation model to be up and running at the beginning of the exploitation phase
2. Fast decision making	There should be fast and efficient operational decision making, recruiting of staff and controlling of costs, by means of avoiding unnecessary layers of governance and ensuring unit of command
3. Robustness	The framework should be resilient to liability and other legal risks. The entity/entities should deliver a high quality, reliable, sustainable service, taking into account the operators and users needs and maximise usage of the satellite signals
4. Evolutivity	The structure should be able to evolve over time, concerning functional structure, regulations, contract, etc.
5. Positive impact on EU economy	Innovation should be promoted, stimulating the EU economy to impact indirect revenues, and possible competition concerns should be controllable
6. Consistency with EU policies and promotion of EU interests	The exploitation structure should ensure strategic independence, be in line with EU objectives in term of risk allocation, while contributing to existing EU policies

#### 7. EU control and accountability

The entity/entities responsible for exploitation of the European GNSS programme must operate at arm's length from the Commission for:

- governance transparency
- control and command of costs in order to avoid future cost overruns
- control of pricing policy (fairness and affordability of those services equated with a mission of general interest)
- management of procurement processes

These governance objectives were defined based on the principles of the Financial Regulation applicable to the budget of the European Communities<sup>58</sup>, particularly taking into account the principle of sound financial management. They were discussed with stakeholders within the working group on future governance (see Annex II for details) in order to set objective and transparent criteria to assess various options for governance.

### 4.3. Consistency with other policies and objectives

The Space Policy Communication of the European Union identified Galileo, EGNOS and GMES<sup>59</sup> programmes as its flagships.<sup>60</sup> The Galileo and EGNOS programmes form an integral part of the Europe 2020 initiative<sup>61</sup> and the Innovation Union initiative<sup>62</sup> as they are intended to push the EU to the forefront by developing innovative ways of exploiting satellite navigation, boosting economic activity in the market further downstream, creating new business opportunities, facilitating the provision of humanitarian aid and enhancing the wellbeing of Europe's citizens (e.g. by making transport safer, increasing civil protection and developing social services for the elderly and the disabled). The benefits of these programmes for the EU cut across all sectors of the economy, such as transport, telecommunications, the environment and security.

Particularly, the GNSS programmes contribute to the **European Transport Policy** as described in the White Paper<sup>63</sup>, fitting in with the sustainable development strategy adopted by the European Council. In this context, the GNSS programmes are highlighted as a project acting as a catalyst for the development of intelligent transport. Interoperable intelligent transport services and systems, on the basis of accurate and reliable positioning that will be offered by the GNSS programmes, are a key tool in the achievement of objectives of safety and fluidity of road traffic. The GNSS programmes are thus instruments essential to the transport development policy.

Concerning the European Transport Policy, specifically the GNSS programmes are major priority projects of the **trans-European transport networks** implementation which the European Union is supporting<sup>64</sup>. They contribute to this development with for instance their potential for traffic management and information for users of the trans-European network and

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<sup>58</sup> COUNCIL REGULATION (EC) No 1525/2007 of 17 December 2007 amending Regulation (EC, Euratom) No 1605/2002 on the Financial Regulation applicable to the general budget of the European Communities, as modified.

<sup>59</sup> Global Monitoring for Environment and Security (GMES) programme aims at achieving an autonomous and operational Earth observation capacity for environment and security. [http://ec.europa.eu/gmes/index\\_en.htm](http://ec.europa.eu/gmes/index_en.htm)

<sup>60</sup> Communication from the Commission COM(2011)152 of 4 April 2011 towards a space strategy for the European Union that benefits its citizens

<sup>61</sup> Communication from the Commission COM(2010)2020 of 3 March 2010 on 'Europe 2020 - A strategy for smart, sustainable and inclusive growth'

<sup>62</sup> Communication from the Commission COM(2010) 546 final of 6 Oct 2010 on 'Europe 2020 Flagship Initiative Innovation Union'

<sup>63</sup> White paper COM(2011) 144 final of 28 Mar 2011 on 'Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system'

<sup>64</sup> Communication from the Commission COM(1999) 54 on 'Galileo - Involving Europe in a new generation of satellite navigation services'; Decision of the European Parliament and of the Council No 661/2010/EU on Community guidelines for the development of the trans-European transport network; White paper COM(2011) 144 final of 28 Mar 2011 on 'Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system'

as an independent radio navigation programme used for highly accurate and reliable positioning.

In addition, also as part of the European Transport Policy, an objective of the European Commission is to create a **European Electronic Tolling Service (EETS)**. It should start offering services by 2012. Satellite navigation can become the preferred technology to realise a unique Europe-wide tolling service. The EU's Interoperability Directive of 2004<sup>65</sup> recommends the combined use of satellite and mobile communication technologies as part of new electronic toll collection systems.

Finally, the global navigation satellite systems are enablers for a number of critical infrastructure sectors such as transport and aviation<sup>66</sup>. The **EU Internal Security Strategy**<sup>67</sup> refers to the Galileo programme in relation to the progress made on security research techniques and technology. The GNSS programmes are also expected to contribute to law enforcement in various sectors. For instance, concerning the monitoring of the fisheries in EU Waters, the Commission Regulation (EC) No 2244/2003 of 18 December 2003 laid down detailed provisions regarding **satellite-based Vessel Monitoring Systems**. These systems aim at monitoring vessels position in order to prevent illegal catches and black landings.

## 5. POLICY OPTIONS

*The implementation of the programmes as defined in the GNSS Regulation which defines the European satellite navigation policy and lays down the objectives of the Galileo and EGNOS programmes is considered to be the baseline scenario. The "no EU action" scenario as described in chapter 3.5 will be analysed as an alternative policy option.*

### 5.1. Policy options for problem 1: Way forward on further implementation and exploitation of the European GNSS programmes

#### 5.1.1. Galileo

The Galileo system has been designed to meet the objectives set in GNSS Regulation and defined in the MRD, as described in the context, section 2.2.1. It is very difficult to re-design a system already in its implementation phase.

To propose alternative policy options, a deviation from these objectives is necessary regarding the number of satellites for space segment and implementation of safety-of-life service features for the ground segment.

The following options to define a way forward on the further Galileo infrastructure implementation could be envisaged:

**A. Space segment:** At Initial Operational Capability (IOC) foreseen in 2014-2015, the 18 already procured satellites should be deployed, against the 30 planned for the Full Operation Capability (FOC). Taking into account that satellites are deployed on three

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<sup>65</sup> Directive 2004/52/EC of the European Parliament and of the Council of 29 April 2004 on the interoperability of electronic road toll systems in the Community

<sup>66</sup> Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection.

<sup>67</sup> COM(2010) 673 of 22 November 2010, Communication from the Commission to the European Parliament and Council: The EU Internal Security Strategy in Action: Five steps towards a more secure Europe.

orbital planes and that they have to be launched at least by pair per orbital plane, determined by the capacity of the Soyuz and Ariane launchers, three theoretically and technically possible final constellations can be examined<sup>68</sup>:

- (A.1) Deploying **18 satellites** as a final constellation;
- (A.2) Deploying **24 satellites** as a final constellation, i.e. launching 6 extra satellites before declaring FOC completion;<sup>69</sup>
- (A.3) Deploying **30 satellites** as a final constellation (cf. the initial FOC target), i.e. launching 12 extra satellites before declaring FOC completion;

**B. Ground segment:** At IOC (2014-2015), only an intermediate ground infrastructure<sup>70</sup> (v2) will be deployed, allowing Galileo to provide navigation signals for OS, PRS and SAR. A subsequent ground infrastructure (v3) is currently planned to be deployed between IOC and FOC to enable the provision of the stand-alone Safety-of-Life service and to implement the full PRS capabilities. Three technically possible ground infrastructure configurations can be examined:

- (B.1) Ground infrastructure, as to be reached at IOC (v2) with **no provision of the SoL-service**;
- (B.2) Ground infrastructure v3 with **SoL service only available in interoperability** with the US GPS (this would require less ground facilities and make the infrastructure simpler, additional information on the SoL re-profiling has been added in annexe VIII);
- (B.3) Ground infrastructure v3 with **SoL service available on a stand-alone basis**;

Other re-designs are not considered, as they would generate significant delays and costs while the implementation has already started.

Not all combinations of these two levers are feasible from a technical point of view: option (B.3) can only be considered with a full nominal constellation, as smaller constellations would anyway not be able to provide a signal accurate enough to provide a stand-alone SoL service. The policy options to be considered for the further deployment of the infrastructure lead to identify final FOC infrastructure. The policy options are outlined in Table 1.

The planning of reaching IOC in 2014-2015 and FOC in 2018-2019 will not be affected (accelerated or decelerated) by any of the options as it is expected that the integration and validation of the system activities will require the same amount of time regardless of the space and ground segment technical characteristics.

**Table 1: Policy options for problem 1**

Option	Space segment	Ground segment	Services
(1) Baseline option	(A.3)	(B.3)	Services can be <b>provided stand-alone</b> as defined in the Galileo Mission Requirements Document
(2) Revised services option	(A.3)	(B.2)	Services can be provided stand-alone as defined in Galileo Mission Requirements Document, except for <b>SoL service that can be provided only in cooperation with GPS</b>

<sup>68</sup> These options refer to the number of satellites deployed at the moment when the full operational capability of the system is declared. The presentation of the options is simplified for the purpose of this report, the system configuration (constellation geometry) related to the number of operational and spare satellites for each of the option is not presented.

<sup>69</sup> The 24 satellite constellation geometry can be optimised depending on the future evolution (24 satellites placed in the 27 initial slots or homogeneously distributed)

<sup>70</sup> The ground infrastructure comprises of over 50 ground stations around the world

(3) Reduced services option	(A.2)	(B.2)	Services can be provided stand-alone <b>but not as defined in Galileo Mission Requirements</b> Document (reduced service level). SoL can be provided only in cooperation with GPS.
(4) Degraded services option	(A.1)	(B.1)	Services <b>cannot be provided stand-alone</b> , only in interoperability with GPS, <b>not as defined</b> in Galileo Mission Requirements Document.
(5) Termination of programme	none	none	none

### 5.1.2. EGNOS

The EGNOS system is already in operational phase, it requires the continuation of operations, maintenance and evolution of EGNOS services during the next years. Therefore two policy options are possible:

- (1) **Continuation of the Programme:** continuation of operations, maintenance and evolution of the EGNOS services
- (2) **Termination of the Programme:** discontinuation of all activities

As EGNOS SoL is already operational<sup>71</sup>, the second option is not further considered: Having declared the Safety of Life service operational, the Commission has engaged the end-user communities in adopting the use of EGNOS. This adoption is leading end-users, in particular in the aviation sector, to heavily invest in adapting their systems to EGNOS: For instance, Eurocontrol is enabling the use of EGNOS by defining its concept of operations, supporting procedures design, conducting a generic safety assessment, supporting EASA in the development of airworthiness and operational approval material, developing an communication tool and managing pre-operational projects.<sup>72</sup>

This calls for a long-term commitment of the Commission to provide EGNOS services. Therefore, in the analysis of impacts all options for the infrastructure completion of Galileo foresee the exploitation of EGNOS, see section 6.1.

## 5.2. Policy options for problem 2: Governance scheme for the exploitation of both Galileo and EGNOS systems

All policy options for the infrastructure completion require a governance structure for the exploitation of the GNSS programmes (Galileo and/or solely EGNOS).

The objective, as defined in section 4.2 is to define a long-term, stable, sustainable governance scheme for the exploitation of both Galileo and EGNOS systems. This governance scheme should be defined by the needs and objectives of the programmes.

Implementing such a new governance framework will require a consequent lead time in order not only to settle legal and administrative issues, but also to build up required capabilities and expertise not existing so far. In order not to cause disruption in the operations, a smooth transition between current deployment governance and exploitation will need to be carefully planned and take place between IOC and FOC.

<sup>71</sup> EGNOS Safety of Life - Service Definition Document: The EGNOS SoL Service is available from the 2nd March 2011

([http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos-sol-sdd-v1.0\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos-sol-sdd-v1.0_en.pdf))

<sup>72</sup> <http://www.eurocontrol.int/press-releases/egnos-operational-aviation>

In order to define this governance scheme a three-step approach has been adopted:

1. **What needs to be done?** Defining a list of functions to be performed during exploitation phase at the levels of political supervision and programme management (chapter 5.2.1)
2. **How should these functions be organised?** Determining how many entities are required to perform all functions identified in the first step (chapter 5.2.2)
3. **What should be the legal form of the entity in charge of European GNSS programme management?** Identifying the most appropriate legal form of the programme management entity that would be adopted for the future exploitation of the programmes (chapters 5.2.3 and 5.2.4)

#### 5.2.1. *Identification of functions to be performed during exploitation phase*

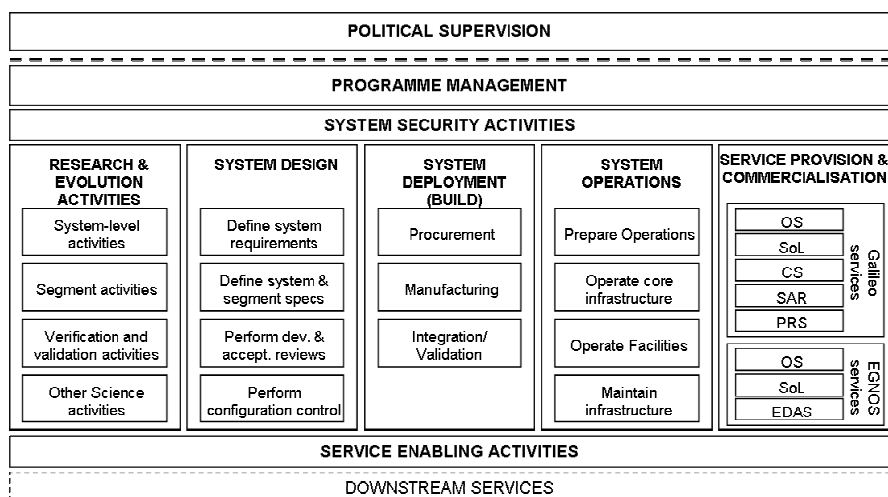
This governance framework has to be defined at two levels:

- **The political supervision level**, in charge of
  - setting the **general objectives** and the associated **mission requirements**
  - deciding on and monitoring the **budget** to be allocated and the **funding mechanisms**
  - ensuring **international cooperation** required by the Programmes
  - setting the proper **delegation of execution activities** at the programme management level
  - **setting and monitoring the security rules** and requirements to be implemented
- **The programme management level**, ensuring that systems fulfil the mission assigned by the political level on time and with target cost. This responsibility covers the coordination and the monitoring of all activities contributing to the mission execution:
  - **research and evolution activities**
  - **system design activities** (Design Authority role)
  - **system deployment activities** to procure all elements and integrate them into a system
  - **system operations** to manage the constellation and the ground facilities
  - **security activities** to ensure the system is not vulnerable to intrusions and attacks
  - **service enabling activities** to allow service provision, define service standards, ensure the certification of the services and monitor system performance
  - **service provision, commercialisation and interface with users**

In order to fulfil the principles and the specific objectives as outlined in section 4.2, the entity in charge of implementing operationally the programme needs to be endowed with a sufficient degree of flexibility and agility as well as with the necessary features to be able to efficiently manage an industrial programme of such magnitude as the European GNSS and to rapidly take decisions. For instance, this entity should be able to attract the right resources and competences and establish specialised teams on new subjects such as system engineering or security management to effectively reach programmes' objectives.



**Figure 2: Functions of political supervision and programme management**



The governance of downstream application markets is not considered in this governance analysis as it has been treated separately in Impact Assessment SEC(2010) 717 of 14th June 2010 on the Action Plan on Global Navigation Satellite System (GNSS) Applications<sup>73</sup>. Because the perimeter of activities to be organised and governed are distinct, exploitation and downstream governances are independent issues.

### 5.2.2. Organisation of the programme management functions

The Exploitation study<sup>74</sup> analysed in detail three potential scenarios with management functions split between one, two or three entities. A comparison of their respective advantages and drawbacks on criteria such as: maximisation of usage, maximisation of direct revenues, operational excellence and efficiency, governance efficiency, conflict avoidance and time for implementation, showed that the integrated model with one single entity responsible for programme management is considered to be more efficient than splitting the responsibilities between infrastructure development and system operations (two entity scenario) or adding a third entity to be in charge of the commercial service (three entity scenario).

The integrated model has been chosen in order to:

- Ensure a consistency between the design of the infrastructure and the operational activities and maximise the coherence and efficiency of the future exploitation entity
- Maximise the control on the operation and the exploitation for the EU (e.g. strategic independence, ownership rights...)
- Maximise the synergies between functions (cost and competences)
- Avoid an excessive split of responsibilities which would not allow to make overall trade-off decisions between available budget, user needs and operational constraints
- Give the EU an opportunity to set up an entity keeping the whole control on the exploitation of the system

<sup>73</sup> This Impact Assessment demonstrated the need for a more extensive action plan to foster the development of EGNOS and Galileo downstream applications and to enhance the quickest, deepest, broadest development of applications across all domains. This was necessary because Europe visibly faces a limited and slow development and adoption of GNSS downstream applications based on the Programmes. The main conclusion was to improve the framework conditions for the market to work through a targeted Action Plan which provided the most adequate remedy to the full range of causes to the problem

<sup>74</sup> Exploitation Study (2009), Roland Berger Strategy Consultants, commissioned by the European Commission.

- Pursue the objectives and principles concerning the governance framework, set in section 4.2

Numerous stakeholders in the exploitation of space infrastructure (e.g. GPS, GLONASS, Skynet 5, Paradigm and Intelsat) support the rationale for an integrated model, in particular for systems whose design requires strong operational coordination.

The results of this analysis were shared and discussed in detail with stakeholders within the working group on the impact assessment (see Annex II for details).

It should be highlighted that assigning responsibility over all activities to one single E1 entity does not determine which activities should be performed internally and which ones should be procured. These decisions should be taken by the management of the future programme management entity.

The responsibility over the management of system security could depart from this integrated functional set-up defined here above in order to better involve Member States in this specific decision making process.

### 5.2.3. *Political supervision*

With the GNSS Regulation, the Commission, on behalf of the European Union is the political body in charge of setting the European GNSS policy. Most existing space systems are currently overseen at national or intergovernmental level: e.g. Eumetsat and Defence systems such as Helios (FR), SAR-Lupe (DE), Paradigm (UK). Commercial space systems are being overseen by private corporate bodies (Inmarsat, Eutelsat) after having been initiated as intergovernmental ones. This transition from public to private body took on average 15 years.

The Commission's proposal for the next multi-annual financial perspective for the EU budget 2014-2020<sup>75</sup> states that the European GNSS programmes shall be fully financed from the EU budget. Consequently, the Commission on behalf of the European Union remains the sole body responsible for overseeing their execution.

### 5.2.4. *Options for programme management*

The European Commission will be responsible for the political supervision of the programmes as described in chapter 5.2.3. There are four options to be considered for programme management:

- (1) European Commission
- (2) EU joint-undertaking
- (3) EU regulatory agency
- (4) EU public company

Through the pre-screening criteria based on the objectives defined in section 4.3, in particular with regard to their feasibility, the following legal options are discarded:

- (1) The **European Commission** is currently managing both the political supervision and the implementation, but this duality will not be sustainable in an exploitation context:
  - In its Special report 2009/7, the European Court of Auditors has highlighted this point: "*The European Commission has proposed itself as programme manager, a challenging role for which it has little experience. While this may*

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<sup>75</sup> COM(2011) 500 of 29.6.2011 "A Budget for Europe 2020"

*be an expedient solution for the short term, the Commission should consider whether this would be the most appropriate long term arrangement";<sup>76</sup>*

- The Commission cannot at the same time be the 'defender of the public interest' authority overseeing the GNSS markets and engage in programme management activities;
- The Commission's organisation and procedures are not fit for managing complex programmes such as GNSS;
- In most national contexts, these tasks are delegated to agencies as there are very few cases where a body in charge of political supervision and policy setting is directly in charge of providing a service;
- In this respect, the creation of an executive agency to which the Commission could entrust programme management tasks for the European GNSS programmes is not an option as the Commission creates it, maintains "real control" over its activity and appoints the key staff. Apart from passing pure implementation tasks to the executive agency the Commission would continue to stay as involved as it is today.

(2) **EU Joint Undertaking** is restricted to the purpose of research and development as stated in article 187 of the Treaty on the Functioning of the European Union (TFEU) which prevents any application for structures in charge of building an infrastructure or operating a service. This option is not feasible and relevant in the context of the exploitation of deployed systems.

Two options will therefore be retained for further analysis:

- (3) EU regulatory agency
- (4) EU public company

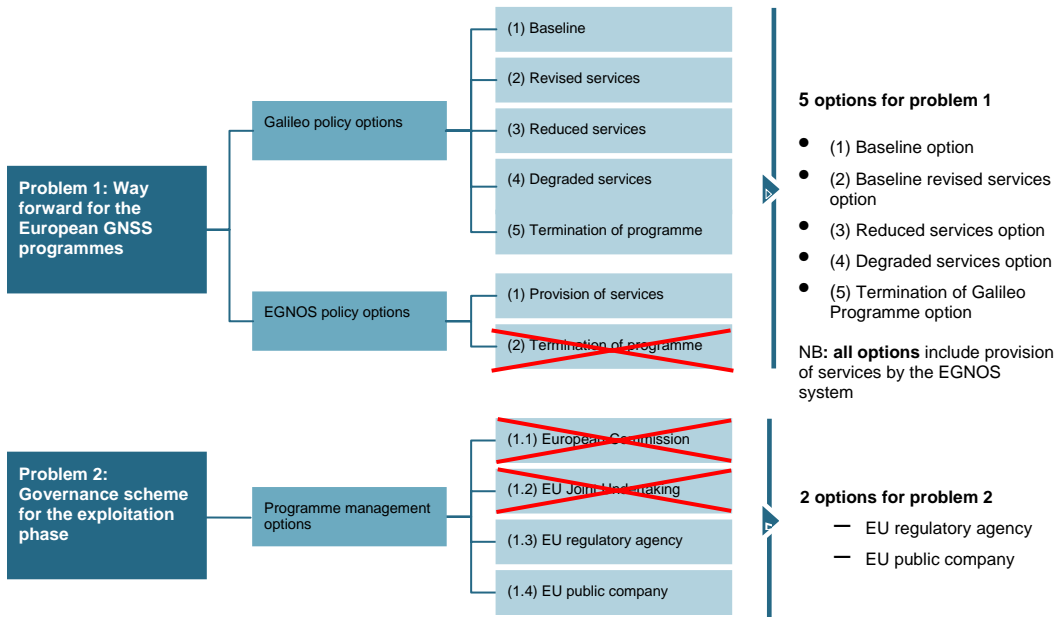
### **5.3. Summary**

An overview of the different policy options to be further studied is presented hereunder:

**Figure 3: Overview of policy options**

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<sup>76</sup> European Court of Auditors, *The management of the Galileo Programme's development and validation phase*, Special Report 2009/7, article 82, p 40



## 6. ANALYSIS OF IMPACTS

### 6.1. Analysis of impacts for problem 1: Way forward on further implementation and exploitation of the European GNSS programmes

The impact of the five FOC infrastructure completion options can be assessed from the point of view of:

- Benefits (indirect benefits and direct revenues) representing economic, social and environmental impacts
- Costs (infrastructure completion and exploitation costs) representing economic impacts
- Competitiveness of the EU industry

The indirect benefits, direct revenues and costs are calculated over a **period of 20 years from 2014 to 2034** in order to take into account a complete lifecycle of the Galileo system, including the replenishment of the constellation and the potential development of a second generation.

#### 6.1.1. Analysis of benefits

##### 6.1.1.1. Availability of services per option

In order to assess the benefits of each option, it is necessary to look at the Galileo service provision per option, the provision of EGNOS services being considered in all options. Simulations have been performed by the European Space Agency to determine the navigation performance, expressed in terms of **navigation accuracy**, which is provided with **certain availability**.

- The final **navigation accuracy** depends on the one hand on the accuracy of measuring the distance between the receiver and the satellites and on the other hand on the number of satellites. Therefore the navigation accuracy differs for each infrastructure option;
- The **availability** can be explained by the percentage of time the accuracy is nominally met. The 99.5 % availability figure means that for the remaining 0.5% (corresponding to a maximum of 1.8 days per year), the performances are not met nominally which entails a degraded performance of the navigation services;

The objectives concerning the performance of Galileo have been set by the Galileo MRD on an accuracy of 4 m horizontally and 8 m vertically (dual frequency service), with an availability of 99.5%. These objectives were based on thorough consultations of end-users in numerous sectors, the availability of 99.5% is linked to the aviations standards for safety-of-life service. By comparison, the GPS has a current accuracy of respectively, 29 m and 53 m (for a single frequency service), with an availability of 99.5%<sup>77</sup>. The following table shows the simulated navigation accuracy per infrastructure option:

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<sup>77</sup> Based on ESA statistical analysis of performance specifications.

**Table 2: Simulated navigation accuracy per Galileo infrastructure option<sup>78</sup>**

(m)/availability 99.5%	Horizontal accuracy		Vertical accuracy	
	Mean accuracy (99.5%)	Worst user-location accuracy	Mean accuracy (99.5%)	Worst user-location accuracy
(1) Baseline option	3.3	3.7	7	7.4
(2) Revised services option	3.3	3.7	7	7.4
(3) Reduced services option	8	25	11.5	30
(4) Degraded services option	80	250	138	451
(5) Termination of Galileo programme	N/A	N/A	N/A	N/A

Option (1) and (2) satisfy the objectives set even for the worst user-locations while option (3) approaches these requirements. The accuracy of option (4) is insufficient for the great majority of users. These values show a strong and fast degradation of performance if the number of satellites is decreased.

In addition, reducing the number of satellites affects **service continuity**: navigation performance at the surface of the Earth is less and less homogeneous and this degradation is not gradual. Service outages at a given point can then last up to several tens of minutes. The simulations carried out by the European Space Agency are provided in the form of maps, which illustrate the navigation performance over the world, see Annex VII.

Furthermore, the **robustness of the system**, i.e. the sustainability of system performance under perturbations such as satellite failure needs to be taken into account. Option (4) will be less robust as the unforeseen breakdown of one or more satellites would strongly deteriorate navigation performance and even mean the inability to provide any service, while options with larger constellations will be less impacted by such events. The probability of having the required number of operational satellites decreases continuously as the constellation ages, and therefore a strategy to maintain the constellation has to be implemented to sustain the system and the performance the EU will have to commit to.

The availability of services to be provided by the Galileo system alone and in combination with the US GPS in various policy options is illustrated in Table 3. This table is based on the information available in September 2011 from the European Space Agency and is deliberately simplified.

**Table 3: Availability of services per infrastructure options**

		Availability of service as per MRD				
		OS	PRS	SAR	CS	SoL
<b>(1) Baseline option</b>	<b>Stand-alone</b>	Yes	Yes	Yes	Yes	Yes
	<i>With GPS</i>	<i>Yes</i>	<i>N/A</i>	<i>Yes</i>	<i>N/A</i>	<i>Yes</i>
<b>(2) Revised option</b>	<b>Stand-alone</b>	Yes	Yes	Yes	Yes	No
	<i>With GPS</i>	<i>Yes</i>	<i>N/A</i>	<i>Yes</i>	<i>N/A</i>	<i>Yes</i>
<b>(3) Reduced services option</b>	<b>Stand-alone</b>	Close to MRD but limited robustness	MRD compliant but limited	Yes	Yes	No

<sup>78</sup> These simulations are dependent on a number of assumptions that will be updated according to how the system will actually perform once deployed, e.g. Orbit Determination and Time Synchronisation (ODTS) accuracy

			robustness			
	<i>With GPS</i>	<i>Yes</i>	<i>N/A</i>	<i>Yes</i>	<i>N/A</i>	<i>Yes</i>
<b>(4) Degraded services option</b>	<b>Stand-alone</b>	Mediocre accuracy and poor continuity	Mediocre accuracy and poor continuity	Yes longer localisation time and poor robustness	Reduced capacity limited to Augmentation	No
	<i>With GPS</i>	<i>Reduced service level</i>	<i>N/A</i>	<i>Reduced service level</i>	<i>N/A</i>	<i>Degraded service level</i>
<b>(5) Termination of the programme</b>	<b>Stand-alone</b>	No	No	No	No	No
	<i>With GPS</i>	<i>N/A</i>	<i>N/A</i>	<i>N/A</i>	<i>N/A</i>	<i>N/A</i>

Service available as per mission requirements
  Service reduced
  Service degraded
  Service not available

It is to be noted that the possibility to interoperate with the US GPS, especially for option (3) and (4), allows an important improvement of this accuracy of the GPS signal but has several consequences:

- The Galileo system will be **partially or fully dependent on interoperability with US GPS**. Europe will not be able to be one of the leaders for the GNSS innovation. It will lose its capacity to influence the future navigation standards and will weaken the competitiveness of its industry in the area of applications and downstream technology developments precisely where most of the navigation market is booming;
- The Galileo system will not become a separate global navigation satellite system as desired by the stakeholders, but rather an **add-on to the US GPS**. Consequently, the failure of one system will impact the combined performance of the systems perceived by the users, taking into account that:
  - The operations of the Russian GLONASS system have suffered large disruptions. It took ten years before it could get its nominal capability back;<sup>79</sup>
  - For the GPS system, the continuous effort to support the system has been also subject to internal US discussions;<sup>80</sup>

These considerations are important if looking at the provision of the OS, PRS and CS services. As regards SAR and SoL services:

- The SAR service is operational with 18 equipped satellites, and thus its performance does not depend on the number of satellites envisaged in the considered infrastructure options, though the degraded option (4) SAR could generate longer localisation time and poor robustness due to potential satellite break down;
- The SoL service alternatives, looking back at section 5.1.1, are mainly depending on the deployed ground infrastructure. Option (1) will be able to provide a stand-alone SoL

<sup>79</sup> The GLONASS constellation reached its optimal status of 24 operational satellites in December 1995. However, in the financially difficult period of 1989–1999, the Russian space program's funding was cut by 80% and, as a result, the constellation reached its lowest point of just 6 operational satellites in 2001. Strong political support led to the progressive restoration of GLONASS capabilities in 2011.

<sup>80</sup> The Governmental Accountability Office pointed out in its report "*Significant Challenges in Sustaining and Upgrading Widely Used Capabilities*", that "*It is uncertain whether the Air Force will be able to acquire new satellites in time to maintain current GPS service without interruption. If not, some military operations and some civilian users could be adversely affected*". The GAO report further noted : "*.. delay in the launch of the GPS IIIA satellites could still reduce the size of the constellation to below its 24-satellite baseline, where it might not meet the needs of some GPS users*"<sup>80</sup>.

service, option (2) and (3) will only be able to provide a SoL service in interoperability with the US GPS and option (4) will not provide the SoL service;

#### 6.1.1.2. Indirect benefits

The European GNSS Agency has developed a GNSS market forecasting and public utility process to address the benefits linked to the options and their service provision. It was developed to provide a solid source of market intelligence on GNSS and to measure the impact of the GNSS programmes and action plans in terms of economic and public benefits.

This model was developed with qualified consulting and economic partners and involved experts from all user segments. A bottom-up approach was followed to develop the model and was complemented with a top-down validation with key industry experts and stakeholders. The data is based on recognised reliable public sources and assumptions are based on experts' consensus. To do so, more than 80 public databases and reports have been consulted and more than 20 experts have been interviewed. The methodology of the model together with assumptions used for calculating the indirect economic, social and environmental benefits are described in detail in Annex VI.

The core indirect economic, social and environmental benefits which will be further monetized can be divided in three main components:

- The **upstream market and spill-over** for the EU-27 region is based on (1) gross value add of investments into space infrastructure within the Galileo programme which result into an increase in disposable income that flows back into the economy via spending on services, equipment and transfer of new technologies and contributes to EU GDP, and (2) spill-over effects of research and development investments.
- The **downstream market** growth for the EU-27 region represents the additional growth of the GNSS applications market that is due directly to the introduction of Galileo. Because the introduction of new technologies has a positive impact on the development of user applications based on these technologies (e.g. introduction of 3G boosted the mobile phones market).
- **Public benefits** for EU-27 region are externalities divergently or indirectly generated by GNSS applications such as benefits for public institutions (VAT, corporate tax), benefits for users (time savings, fertilizer reduction) and benefits for society (CO2 reduction, noise reduction)

Total cumulative monetised indirect benefits of the GNSS programme were calculated for a period based on a methodology detailed in Annex VIII in constant prices 2011 for a period of 20 years from 2014 to 2034, see Table 4.

**Table 4: EGNSS indirect benefits per option – 2014-2034**

(EUR bn/constant prices 2011)	<i>Economic benefits</i>		<i>Social and env. benefits</i>	<b>Total benefits</b>
	Upstream market growth	Downstream market growth	Public benefits	
(1) Baseline option	19.94	26.43	87.41	133.77
(2) Revised services option	19.94	26.43	87.41	133.77
(3) Reduced services option	17.30	20.64	73.43	111.37
(4) Degraded services option	14.83	15.36	64.84	95.04



(5) Termination of Galileo programme	6.76	1.27	15.02	23.05
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Source: European GNSS Agency

EGNOS indirect benefits are included in all options. The last option implies Galileo programme termination, but EGNOS is exploited and services are offered. EGNOS is consequently the only driver of the benefits for option (5).

There is an estimated upside potential of EUR 46 billion in total through the acceleration of the GNSS market growth for options 1 and 2, but an active industrial policy is required to capture this upside. The Commission action plan designed in this respect has been dealt with in the Impact Assessment SEC(2010) 717 of 14th June 2010 on the Action Plan on Global Navigation Satellite System (GNSS) Applications.

The GNSS market forecasting and public utility tool can also estimate the general potential social and environmental impacts as non-monetised public benefits. However, the results of the model are applicable only to the baseline option as adjustments to reflect the other options were not done. Consequently, the results of the non-monetised indirect benefits estimations were not used as an argument in assessing the impacts of different policy options.

For illustration, the potential social and environmental impacts of option 1 are the following:

- 6,000 jobs (Net jobs creation from 2015-2027)
- 8,500 saved lives (Cumulative until 2027)
- 2,000,000 lives improved (Average from 2015-2027)
- 1,2 trillion m<sup>3</sup> of water saved (Cumulative until 2027)

#### 6.1.2. Direct revenues

Apart from indirect benefits, direct revenues are expected to be generated through the services provided by the GNSS programmes. The Exploitation study<sup>81</sup> analysed possible revenue streams and indentified the **Commercial Service** (CS) and the **Public Regulated Service** (PRS) as the two services expected to potentially generate direct revenues:

- The PRS revenues mechanisms (license fees on receivers, activation fees on receivers and access fees to signal) have been quantified based on the number of countries and users communities (defence, emergency services, law enforcement...) adopting the PRS
- Two revenue mechanisms have been assessed for the Commercial Service, based on various underlying markets. Revenues relate to access fees for authentication services and High Precision Positioning Service (HPPS)

The revenue analysis is based on a methodology that took into account conservative assumptions in quantifying direct revenues by taking into account only services that are currently being developed. The rationale behind this approach is to avoid overestimating these revenues and to avoid creating assumptions that in the medium term the European GNSS programmes can be fully self-financed. Such assumptions in the past led to initiate the public-private partnership that eventually collapsed (see chapter 2.2).

The expected evolution of revenues from public regulated service and commercial service over time is not beyond EUR 1.61 billion during the 20 years period, which amounts to less than 10% of the total costs for the next 20 years. It is clear that the European GNSS will not be profitable enough to be run on an independent basis and public financing of costs will be

<sup>81</sup> Exploitation Study (2009), Roland Berger Strategy Consultants, commissioned by the European Commission.

necessary in the future. The direct revenues will never have the potential to offset the operation costs of the programmes as detailed in chapter 6.1.3.

It is to be noted that only direct revenues, i.e. where the Galileo service centre is able to identify charged users and automatically deny access to non paying users, have been taken into account. Additional indirect revenues for services where automated denial of access is hardly conceivable (e.g. Safety of Life) could be envisaged through indirect charging mechanisms. As there is no legal framework for such mechanisms, indirect revenues are not considered for the purpose of this impact assessment.

On the basis of these conservative assumptions, European GNSS direct revenues will account for EUR 78-83 million a year on average in constant prices 2011 in the next 20 years (2014-2034) period for policy options that provide both the PRS and the Commercial Service (see Table 5).

**Table 5: EGNSS potential direct revenues per option**

(EUR bn)/constant prices 2011	PRS min. and max. revenues	CS revenues	Total 2014-2034
(1) Baseline option	0.24 – 0.34	1.32	1.61
(2) Revised services option	0.24 – 0.34	1.32	1.61
(3) Reduced services option	0.24 – 0.34	0.00	0.28
(4) Degraded services option	0.00	0.00	0.00
(5) Termination of Galileo programme	0.00	0.00	0.00

Potential revenues from the aviation sector could also be expected from the SoL service offered by Galileo as this service could gradually replace existing infrastructure supporting aviation navigation and some landing approaches. However this possibility and the level of these potential revenues can only be analysed once the final characteristics of the re-profiled service will be available.

Potential additional revenues which could be expected from new features developed for next generation of Galileo systems, such as commercial telecommunication thanks to telecommunication payloads incorporated into Galileo satellites, have not been taken into account. Indeed the possibility that these revenues occur depends on technical requirements which have not been thoroughly analysed yet.

### 6.1.3. Analysis of costs

The options vary regarding the number of deployed satellites and the specifications of the ground segment. These changes have an impact on the total cost of the programme. For each option, costs have been assessed not only for the completion of the infrastructure, but also for the following exploitation of the system:

- **Cost to complete the Galileo infrastructure:** cover the activities to finalise the deployment phase of the programme in order to reach the full operational capability of the Galileo system by 2018-2019.
- **Exploitation costs:** cover the exploitation phase for both Galileo and EGNOS systems, comprising of operational management of the infrastructure, management of the services and the replacement, renewal of components with a limited service life, infrastructure protection (space situational awareness) They also include system

evolution i.e. ongoing improvements to the systems so as to adapt services to the changing needs of users. The exploitation of the EGNOS system is ongoing, Galileo system is expected to reach initial operational capacity and to provide early services in 2014-2015.

These costs are assessed based on a detailed internal methodology comprising of different cost groups for both Galileo and EGNOS programmes based on constant 2011 prices. The Galileo costs were segmented into 9 clusters (System Support, Ground segment, Satellites, Launchers, Operations, Site Hosting, Management, New Generation Development and Other costs) and EGNOS costs. Each of the segments was analysed in detail, consisting of several cost drivers. For example, for the Ground segment in Galileo costs the main capital expenditure drivers are extension of the ground segment network, deployment of sites, full software qualification, and performance qualification. The EGNOS costs were based on extension of the coverage of the system and operation costs of the system. On the top of these costs, the impact of risks and contingencies were quantified, divided into space segment risks (launch, separation, in orbit transition, satellite failure) and other risks (system development and operation/maintenance risks).

This complex methodology has been developed over more than two years. All assumptions and cost drivers were presented in detail to representatives of Member States during meetings of the management committee in 2009 to 2011 and a number of dedicated bilateral meetings in 2011. These meetings were welcomed by MS departments which were impressed by the level of details and the robustness of all assumptions taken.

The costs are modelled over a twenty-year period in order to take into account a complete lifecycle of the Galileo system, including the replenishment of the constellation and the potential development of a second generation. To reflect this, the cost estimations are divided according to 7-years periods of the EU multiannual financial frameworks (MFF 2014-2020, and jointly for MFF 2021-2027 and MFF 2028-2034), as shown in Table 6. The termination of the Galileo programme also implies costs concerning contract cancellation, fees, dismantling costs, etc. next to the exploitation costs for EGNOS.

**Table 6: European GNSS programmes costs per option 2014-2034**

(EUR bn)/constant prices 2011	EU MFF 2014-2020	EU MFF 2021-2034	<b>Total</b>
(1) Baseline option	7.8	12	19.8
(2) Revised services option	7.0	11.5	18.5
(3) Reduced services option	6.5	10.8	17.3
(4) Degraded services option	5.6	10	15.6
(5) Termination of Galileo programme	2.4	1.4	3.8

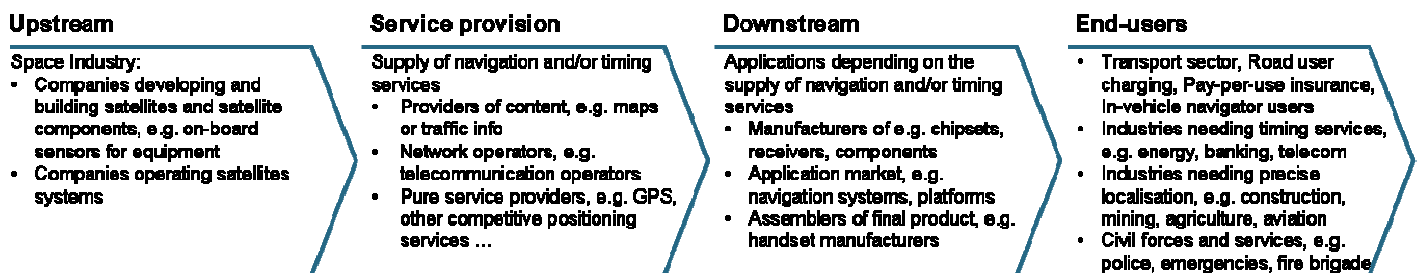
#### 6.1.4. Sector-specific impacts

Generally speaking, the EU industry benefits from whatever enables it to reduce its costs, lower its prices, develop new products / services and/or improve its marketing, sales, after-sale model. This however does not automatically translate into an improvement of EU international competitiveness. Competitiveness is a relative concept: EU industry is competitive by comparison with non-EU industries on the EU market and abroad. Its international competitiveness will therefore only improve if it makes faster and bigger progress than its non-EU competitors in terms of cost/price, innovative and/or commercial competitiveness.

Whenever possible and appropriate, the analysis reviews in particular the impact on the competitiveness of the sector(s) targeted by the initiative, their suppliers (upstream sectors) and their clients (downstream sectors and end-users). In the present case, this value chain analysis encompasses four main segments:

- **Upstream:** European space industry contributing to the building of the global satellite navigation system
- **Service provision:** European industry supplying commercial or public service positioning, navigation or timing services
- **Downstream:** European applications industry depending on service provision supplying hardware and software needed to exploit satellite signals
- **End-users:** industries using services and applications

**Figure 4: Value-chain of industries affected by the GNSS programmes**



Particular attention is devoted to the European applications industry and to end-users, where the biggest competitiveness impact is expected, applying a general argumentation as is used for the other parts of the value chain<sup>82</sup>.

The competitiveness impact of the various options has been reviewed through a set of key questions including:

- **Cost/price competitiveness:** Could the implementation of the GNSS programmes increase competition among data providers & supporting industries? Could it lower the costs of doing business in Europe for certain downstream sectors? Could it increase their productivity?
- **Innovative competitiveness:** Could the implementation of the GNSS programmes encourage product innovation, process innovation, leading to the creation of new markets or the establishment of new EU industrial sectors?
- **Commercial competitiveness:** Could the implementation of the GNSS programmes open new opportunities for EU industry's marketing, branding, ...?

From a competitiveness viewpoint, the 5 infrastructure options identified in section 5.1 can be grouped into three clusters as depicted in Figure 5.

**Figure 5: Clustering of infrastructure options used to review sector-specific impacts**

<sup>82</sup> cf. Annex IV – Sector-specific impacts

### 1 - Baseline option

- 30 satellites (27+3 in-space spares) and a full GMS v3 allowing to deliver the 5 services defined in Regulation (EC) No 683/2008

### 2 - Baseline revised services option

- Full constellation with provision of the 5 services. However, there is no deployment of the Galileo integrity concept, requiring to develop an alternative SoL concept

### 3 - Reduced services option

- 24 satellites with the full provision of OS, SAR, PRS. The CS will be available with capabilities depending on the ground segment. The SoL will be provided with reduced capability

### 4 - Degraded services option

- IOC configuration of 18 satellites, allowing the provision of early OS, PRS and SAR services with partial performance without meeting nominal Mission requirements

### 5 - Termination of programme

- No provided services for Galileo (EGNOS services are offered)

Complete or nearly complete constellation to provide all services defined in Regulation (EC) No 683/2008

Degraded system

No system

Options (1) and (2) are likely to boost significantly EU innovative competitiveness, with the creation of new markets/business sectors. A positive impact is also expected in terms of cost and price competitiveness (for a high-level summary of the results of likely impacts on the competitiveness of the various sectors concerned, see Table 7 for a general presentation of the analysis and detailed examples, part 1)

In order to illustrate the likely impact on EU industrial competitiveness, a sectoral analysis has quantified the impact of GNSS based applications on the market dynamics (see part 2). As an example, GNSS road transport is a wide-ranging and complex market segment combining mass-market applications (in-vehicle navigation) and commercial applications. Moreover, GNSS is an enabling technology for intelligent transport systems (ITS) including road user charging.

The development of an European GNSS industry would stimulate competitiveness through **innovation**. Technological innovation and new e-business models could significantly shift the relative importance of the different markets and/or promote emergence of new business models. For instance, GNSS tracking systems can be applied to insurance in obtaining time usage and location travelled by insured vehicles. This will permit insurance companies to create pay per usage policies.

It would also stimulate competitiveness through **productivity gains**. The rise of the road user charging based on GNSS solutions will lead to fulfilling the governments' objectives of reducing traffic congestions and its collateral damages to the economy and the environment, while motorway operators will improve the cost-effectiveness of their toll collection systems. Such systems already exist for instance in Germany and Austria, but these are based on signals that can be spoofed, while the introduction of Galileo will allow the operators to limit the level of fraud by its authentication and integrity features.

These two example technologies are emerging and will contribute to the growth of the GNSS road market to ~€30 bn worldwide by 2020 with an annual growth of 13.4%. The biggest driver for this growth will be the in-vehicle navigation market. The personal navigation device penetration rate in cars should reach 80% by 2015 while in-vehicle devices will continue to growth to 50% by 2025, with a continuous technologic evolution towards

dynamic route navigation and anti-theft features, improving safety, comfort and effectiveness of road travelling.

**Table 7: Summary of the competitiveness impact**

	(1-2) Baseline and revised services options	(3-4) Reduced and degraded services options	(5) Termination of Galileo programme
Upstream	++	+	-
Service provision	++	+	-
Downstream	+	+	-
End-users	++	+	0
<b>Total</b>	++	+	-

- : negative impact on competitiveness

+ : positive impact on competitiveness

## 6.2. Analysis of impacts for problem 2: Governance scheme for the exploitation of both Galileo and EGNOS systems

While the choice of a way forward on the further implementation of the European GNSS infrastructure (Problem 1) can be measured in terms of direct and indirect environmental, economic and social impacts against required resources, the impact assessment of the choice of a legal and financing framework is less straightforward for various reasons:

- The impact of the choice of a legal forms cannot be measured against quantitative factors, nor can causal relationships be identified;
- Programme costs and in particular required public sector human resources have been quantified against a work breakdown structure and not adjusted according to a legal structure. The cost analysis makes the assumption that an activity requiring one full-time equivalent in an intergovernmental organisation should require the same workload in an EU regulatory agency;

On these grounds, measuring the impact of a specific legal form should aim at identifying the most efficient, effective, coherent legal and financing framework for managing the exploitation of the European GNSS programmes. Therefore, the options for problem 2 will be assessed qualitatively in terms of their compliance with the objectives as outlined in section 4.2. On these grounds, the impact of a specific legal form will be identified and expressed in terms of their effectiveness, efficiency and coherence with the legal and financing framework for managing the exploitation of the European GNSS programmes.

### 6.2.1. EU Regulatory agency

Regulatory agencies have a variety of specific roles<sup>83</sup>, set out in their own legal basis, case-by-case (as opposed to executive agencies, which are set up under Council Regulation 58/2003 to help to manage Community programmes<sup>84</sup>). There are no general rules governing

<sup>83</sup> The Committee on Budget of the European Parliament, in its 2009 opinion on the Report on financial management and control of EU agencies (2008/2007 (INI)), stresses that "*the term "regulatory agency", which is increasingly used as a generic term, is misleading, as not all decentralised agencies have regulatory tasks*". It prefers the term "*decentralised agencies*". Indeed, some of these agencies have operating tasks, as ERA, GSA, CFCA, FRONTEX, EUROJUST, EUROPOL and CEPOL.

<sup>84</sup> OJ EU L11/1 of 16.1.2003

the creation and operation of regulatory agencies to date although this has recently been proposed by the Inter-institutional Working Group on Agencies<sup>85</sup>.

In terms of effectiveness and coherence, EU regulatory agencies allow a strong coherence between the European GNSS programmes' exploitation and EU policies as well as offer per se an assurance of EU control and accountability as they are directly responsible to the discharge authority, the European Parliament, for budget implementation.

Regarding efficiency, while the general pattern of regulatory agencies has a clear interest in terms of operational flexibility, in particular for human resources policy, the current legal framework, and in particular the EU Financial Regulation, is not fully adapted to the management of large scale infrastructures notably as far as the procurement framework is concerned.<sup>86</sup>

While this assessment applies to regulatory agencies in the general sense, it is clear that the European GNSS Agency (GSA) is the most suitable candidate amongst these and will require particular attention when developing a concrete proposal for the governance of EGNOS and Galileo. The reasons for this are

- the GSA's present involvement in the GNSS programmes and its already existing foundations of competence;
- the general concerns over the growth in the number of EU agencies which make it unlikely that Parliament or Council will accept the creation of a new agency;
- the concern that best use should be made of existing governance structures in the GNSS programmes, as stated in Council's Conclusions on the Mid-term review of the European GNSS programmes.<sup>87</sup>

This said, it has also to be underlined that the GSA in its current form is not in a position to take over the governance of Galileo and EGNOS. Bearing in mind that the current mandate of the GSA is limited to security and market related issues, its tasks and decision making bodies would need to be redefined to manage the GNSS programmes. Also, the GSA currently does not have the appropriate financial and human resources to carry out programme management tasks under its own capacity.

Therefore and to secure smooth and gradual transition, the Commission could consider taking preparatory steps to enable the GSA to acquire the necessary competence and credibility for its future role before the new legislative act enters into force (2014). This could for example take the form of the delegation of tasks linked to the programmes in accordance with article 16 c) of the GNSS Regulation. A scenario to be considered is notably the early transfer of activities related to the management of the EGNOS programme and/or of the preparation of

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<sup>85</sup> See European Parliament Conference of Presidents meeting minutes 05.05.2011, agenda item 5.1: [http://www.europarl.europa.eu/RegData/organes/conf\\_pres\\_groupes/proces\\_verbal/2011/05-05/CPG\\_PV\(2011\)05-05\\_EN.pdf](http://www.europarl.europa.eu/RegData/organes/conf_pres_groupes/proces_verbal/2011/05-05/CPG_PV(2011)05-05_EN.pdf)

<sup>86</sup> See recommendation 1620 of Internal Audit Service's Audit of the GNSS Programmes (part: Governance, Risk Management and Project Management) of 14 April 2011 (Commission-internal document) which refers in particular to the use of firm fixed price contracts and to the inflexibility of budgetary periods.

<sup>87</sup> These call upon the Commission "to optimize and rationalize the use of existing structures and to give particular attention to the operational governance of EGNOS". Ref. idem footnote 26, see also Annex V for a link to the Conclusions.

Galileo operation, notably for the early services, subject of course to the GSA being endowed with the necessary resources.

### 6.2.2. *EU public company*

A European public company, that is to say, a company with shares at least partly held by the European Union would raise significant issues in terms of feasibility:

- While purely corporate matters would be subject to the corporate law of the country of incorporation, rules would have to be established in EU law (as is the case in most Member States) with respect to issues such as governance, the opening of share capital and privatisation. Also, the status of EC civil servants seconded in the company would need to be clarified. However, for the creation of a status of an 'EU public enterprise', i.e. of corporations controlled by the Commission there are neither precedents nor clear rules;
- The complexity of the work that would have to be undertaken is illustrated by the areas for which legislation would have to be proposed, including (i) defining the procedure and conditions of approval of the investment of the EU in a company, (ii) determining the conditions of governance of the company, (iii) spelling out the rules applicable to the privatisation of such company and (iv) clarifying and if necessary extending the mandate of the European Court of Auditors (as defined by art. 287 TFEU) to cover also the EU public enterprise.<sup>88</sup> In short, the creation of an EU public enterprise will likely require putting in place a specific branch of EU law, a task that would need many years to be accomplished;
- Furthermore, establishing an EU public company will raise the same liability and tax issues as a private company;
- Finally, the operation of such company would continue to be based on the national law of its Member State of incorporation, raising questions as to its ability to fend off legal claims and attacks from hostile competitors. Also, in case of insolvency procedures these would be governed by the relevant domestic law, and the EC would have no or limited control on the liquidation of the company although its liabilities could ultimately be imputed to the EU.

In short, while an EU public company could have the advantages of a private sector company in terms of effectiveness and efficiency in the commercialisation of services, it raises questions as to the feasibility of putting in place the legal prerequisites in a timeframe that is useful for the GNSS programmes.

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<sup>88</sup> Although article 287 TFEU provides that the mandate of the European Court of Auditors extends to "*bodies, offices or agencies set up by the Union, in so far as the relevant constituent instrument does not preclude such examination.*" Whether a company owned by the EU could be regarded as being among such categories could be challengeable.


















## 7. COMPARING THE OPTIONS


### 7.1. Comparing the options for problem 1: Way forward on further implementation and exploitation of the European GNSS programmes


#### *Effectiveness*

Effectiveness related to compliance of policy options with the general policy objectives is based on a qualitative comparison of the technical characteristics of the options and their impacts as described in chapter 6.1 in combination with detailed information on effectiveness in Table 10. In Table 8 below the main findings are summarised: the difference between options (1) and (2) is in the provision of the safety-of-life service which in option (2) can be only provided in cooperation with GPS while all other services can be provided on the standalone basis. As regards the resilience of the EU economic infrastructure both options 1 and 2 are equally fulfilling the criterion in both options a full backup system of the signal will be provided in case there is a signal disruption from other systems. The sustainability of system performance under option (3) for the open service and PRS is weak, impacting the resilience of the EU economy relying on such a system. Option (4) can only partially demonstrate Europe's ability to deploy and operate a global navigation system while the other two policy objectives are not achieved at all as the services would have very poor quality and the economic resilience would not be reinforced.

**Table 8: Compliance with general policy objectives**

	Set up an Independent GNSS		Increase resilience of EU economic infrastructure		Build Europe's technical GNSS capability	
<b>(1) Baseline</b>		100%		100%		100%
<b>(2) Revised services</b>		75%		100%		100%
<b>(3) Reduced services option</b>		75%		50%		100%
<b>(4) Degraded services option</b>		0%		0%		25%
<b>(5) Termination of Galileo prog.</b>		0%		0%		0%

: No compliance to objective

: Full compliance with objective

#### *Efficiency*

Efficiency of the policy options is assessed based on the indirect benefits, direct revenues and costs which depend for each option on the number and quality of the services enabled. As the cost-benefit analysis in Table 9 shows, the associated cost containment between options appears to be rather low. This can be explained by the inflexibility of the ground segment design which offers poor cost containment opportunities resulting into overall low cost elasticity of the options. The difference in costs between option (1) and option (2) for a period 2014-2034 is less than one billion EUR while delivering same indirect benefits. Option (3) in comparison to option (1) costs two billion EUR less while the difference in indirect benefits is much more substantial. Finally, the most degraded option (4) decreases cost by only 20%, while having 30% decline in indirect benefits.

In compliance with the Impact Assessment guidelines<sup>89</sup>, all cost, revenue and benefit figures in this chapter are discounted at a rate of 4% starting in 2014, though it alters the amount of

<sup>89</sup> European Commission, Part III: Annexes to Impact Assessment guidelines, 15 January 2009, chapter 11.6 p71

budgetary needs expressed for the next Multiannual Financial Framework by artificially decreasing them.

**Table 9: Cost-benefit analysis of policy options: 2014-2034**

(EUR bn) Constant prices 2011 and discounted prices at 4%	Indirect benefits		Direct revenues		Costs		Net benefits	
	Constant prices	Discount. prices	Constant prices	Discount. prices	Constant prices	Discount. prices	Constant prices	Discount. prices
(1) Baseline	133.77	81.26	1.61	1.05	19.8	14.65	115.58	67.66
(2) Revised services	133.77	81.26	1.61	1.05	18.5	13.69	116.88	68.63
(3) Reduced services option	111.37	67.59	0.28	0.20	17.3	12.80	94.35	54.99
(4) Degraded services option	95.04	57.53	0.00	0.00	15.6	11.54	79.44	45.99
(5) Termination of Galileo programme	23.05	14.00	0.00	0.00	3.8	2.81	19.25	11.19

### *Coherence*

Coherence of the policy options with EU objectives, strategies and priorities is detailed in Table 10. There is no difference on this aspect between options (1) and (2) as both are in line with the EU political framework, have a high positive effect on the competitiveness of the EU industry and have a potential for strategic benefits for the EU. Options (3) and (4) are similar: partially inconsistent with the EU objectives and priorities and with medium positive effect on competitiveness. Option (5) – termination of the Galileo programme – is not at all consistent with the declared EU objectives and has a negative impact on competitiveness.

### *Summary*

Taking into account all impacts, aspects of efficiency, effectiveness and coherence compared in Table 10 and in particular the potential cost savings, it appears that the **option (2) – Revised services is the preferred option.**

**Table 10: Effectiveness – Efficiency – Coherence comparison for problem 1**

	Effectiveness	Efficiency	Coherence
<b>(1) Baseline option</b>	<p><b>Achieves all general and specific objectives:</b></p> <ul style="list-style-type: none"> <li>- an independent GNSS, maximise indirect economic benefits and demonstrate Europe's ability to develop, deploy and operate a complex large-scale infrastructure,</li> <li>- <b>services comply with the mission requirements and the GNSS regulation.</b></li> </ul>	<p>Costs of 19.8 bn EUR will be offset by high indirect benefits of 133.7 bn EUR in 20 years</p>	<p>The long-term investment would enable <b>positive trade-offs</b>, especially concerning indirect benefits.</p> <p>Full development of industrial, technical and scientific capabilities and a <b>high positive effect on competitiveness</b> of EU industry.</p> <p><b>Coherence with political agenda and EU objectives</b> (e.g. Treaty of Lisbon, Europe 2020, European Transport policy, etc.).</p> <p>Potential for <b>strategic benefits</b> for the EU as global actor.</p>
<b>(2) Revised services option</b>	<p><b>Achieves most of general and all specific policy objectives:</b></p> <ul style="list-style-type: none"> <li>- the SoL service can be only provided through cooperation with GPS, hence the European GNSS <b>not truly independent</b></li> <li>- maximise indirect economic benefits and demonstrate Europe's ability to develop, deploy and operate a complex large-scale infrastructure.</li> <li>- <b>services comply with the mission requirements and the GNSS regulation</b> (except for independence of SoL service)</li> </ul>	<p>Costs of 18.5 bn EUR will be offset by high indirect benefits of 133.7 bn EUR in 20 years</p> <p><b>Most efficient solution regarding the cost – benefits analysis</b></p>	<p>The long-term investment would enable <b>positive trade-offs</b>, especially concerning indirect benefits</p> <p>Full development of industrial, technical and scientific capabilities and a <b>high positive effect on competitiveness</b> of EU industry</p> <p><b>Coherence with political agenda and EU objectives</b></p> <p>Potential for <b>strategic benefits</b> for the EU as global actor</p>
<b>(3) Reduced services option</b>	<p><b>Does not achieve all general and specific objectives:</b></p> <ul style="list-style-type: none"> <li>- there is no independent GNSS, indirect economic benefits are not maximised, but it does demonstrate Europe's ability to develop, deploy and operate a complex large-scale infrastructure</li> <li>- if Galileo is to provide the services independently, some are reduced or degraded, so <b>no achievement of full mission requirements on all services</b></li> </ul>	<p>Costs of 17.3 bn EUR will be offset by indirect benefits of 111.3 bn EUR in 20 years</p>	<p>The long-term investment would enable <b>positive trade-offs</b>, especially concerning indirect benefits – but <b>less</b> if compared with the baseline</p> <p>Medium development of industrial, technical and scientific capabilities and a <b>medium positive effect on competitiveness</b> of EU industry</p> <p><b>Partly inconsistent with the EU declared ambitions</b> with Galileo being its flagship programme in the space policy and its contribution to the Europe 2020 initiative</p>
<b>(4) Degraded services option</b>	<p><b>Does not achieve all general and specific objectives:</b></p> <ul style="list-style-type: none"> <li>- there is no independent GNSS, indirect economic benefits are not maximised, but it does demonstrate Europe's ability to develop, deploy and operate a complex large-scale infrastructure</li> <li>- if Galileo is to provide the services independently, some are reduced or degraded, so <b>no achievement of full mission requirements on all services</b></li> </ul>	<p>Costs of 15.6 bn EUR will be offset by indirect benefits of 95 bn EUR in 20 years</p>	<p>The long-term investment would enable <b>positive trade-offs</b>, especially concerning indirect benefits – but <b>less</b> if compared with the baseline</p> <p>Medium development of industrial, technical and scientific capabilities and a <b>medium positive effect on competitiveness</b> of EU industry</p> <p><b>Partly inconsistent with the EU declared ambitions</b> with Galileo being its flagship programme in the space policy and its contribution to the Europe 2020 initiative</p>

**(5)  
Termination  
of Galileo  
programme**

**Does not achieve neither general, specific nor operational objectives, only EGNOS is available**

Costs to terminate the Galileo programme, cost of 3.8 bn EUR to operate EGNOS with minor indirect benefits in 20 years

**Loss of many potential positive impacts** on economic, social and environmental matters  
No development of industrial, technical and scientific capabilities and a **negative effect on competitiveness** of EU industry and on the European space industry  
**Strongly inconsistent with the previous EU efforts in the space policy**, would be coherent only in case of a major shift of policy priorities in the EU

## **7.2. Comparing the options for problem 2: Governance scheme for the exploitation of both Galileo and EGNOS systems**

The summary and comparison of possible legal set-ups for programme management and their compliance with objectives set in section 4.2 is in Table 11.

Following the comparison of impacts of the EU Regulatory Agency and EU public company, it can be concluded that the **EU regulatory agency** is the most appropriated to fulfil the objectives of programme management as this set-up is highly coherent, effective and efficient from an EU point of view. As mentioned in chapter 6.2.1, the most appropriate existing EU regulatory agency to take on the programme management tasks is the European GNSS agency.

**Table 11: Effectiveness – Efficiency – Coherence comparison for problem 2**

<b>Baseline option: EU political supervision</b>			
	<b>Effectiveness</b>	<b>Efficiency</b>	<b>Coherence</b>
EU Regulatory Agency	<ul style="list-style-type: none"> <li>• <b>Strong feasibility:</b> requires only ad-hoc EU legal basis to be established</li> <li>• <b>Fast decision making</b> through establishment of Administrative Board and Executive Director</li> <li>• <b>Strong robustness:</b> Proven legal scheme. Under umbrella of Art 340 and 343 of Treaty on the Functioning of the European Union</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Medium evolutivity,</b> requiring amendments of the EU legal basis establishing the agency</li> <li>• <b>Positive impact on EU economy:</b> Focus put on maximise diffusion of services and indirect revenues. However, to ensure efficiency, the agency will need to operate under ad-hoc rules in areas such as public procurement and human resources</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Strong consistency with EU policies:</b> EU rules governing regulatory Agency establish objectives to be pursued. Commission would have ability to control work programme of Agency to ensure <b>consistency with EU policies</b></li> <li>• <b>Strong EU control and accountability:</b> Through its supervision mandate on behalf of the EU, the Commission tightly control budget allocation, use of appropriations, etc. and the agency is subject to the control of the European Court of Auditors</li> </ul>
EU public company	<ul style="list-style-type: none"> <li>• <b>Very poor feasibility:</b> Neither precedent nor clear rules for the EU to create an EU public company. Lead time required to develop the legal framework is not compatible with the time perspective of early exploitation (2014-2015).</li> <li>• <b>Fast decision making and flexibility</b> similar to the ones of private sector companies</li> <li>• <b>Poor robustness:</b> the operation of such company would be based on the national law of its Member State of incorporation, far less likely to be able to fend off legal claims and attacks from hostile competitors, difficult to wind up. It may face bankruptcy, contrary to an EU organ. Liabilities ultimately imputed to the EU in case of an undertaking under EU control</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Poor evolutivity:</b> requiring amendments to the legal framework. Winding up of the EU public company would be very difficult as well as a transition to another public body.</li> <li>• <b>Ambiguous impact on EU economy:</b> the EU public company will focus in the first place on maximising revenues and minimising expenditures, the indirect benefits for the EU economy are secondary.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Medium consistency with EU policies and EU control and accountability:</b> EU ownership seems a good preservation of the main shareholder interests , however, the identity of views is even better in the EU Regulatory Agency configuration where the EU has a direct hand on the management of the entity</li> </ul>

## 8. MONITORING AND EVALUATION

The proposal, once adopted, will lead to the further implementation of the European GNSS programmes. Evaluation of these programmes will look into the achievements on a wide and diverse scale.

### 8.1. Indicators

Indicators related to fulfilment of specific policy objectives focus on the output – services to be enabled by the Galileo and EGNOS programmes, the efficiency of their delivery and the effectiveness of the governance scheme managing them. Detailed indicators for global policy objectives are described in the Action Plan on Global Navigation Satellite System Applications<sup>90</sup>

**Table 12: Indicators**

Level of objective	Type of indicator	Indicator
Specific policy objective	Output indicator	<ul style="list-style-type: none"><li>- Characteristics, quality and specifications of the services of Galileo are in line with the GNSS regulation and the Mission Requirements Documents</li><li>- Characteristics, quality and specifications of the services of EGNOS are in line with the GNSS regulation and the Mission Requirements Documents</li><li>- The services of Galileo and EGNOS are delivered -target costs and on-target date delivery</li><li>- The governance scheme for exploitation of Galileo and EGNOS is stable, sustainable and efficient</li></ul>
General policy objective	Result indicator	<ul style="list-style-type: none"><li>- Competitiveness of the European based GNSS industry Widespread use of the services (market penetration, number of jobs created, market share etc.)</li><li>- Indirect and direct benefits enabled by the GNSS programmes</li></ul>

### 8.2. Monitoring and evaluation

The Commission will ensure that all contracts and agreements concluded in the framework of the GNSS programmes will provide for supervision and financial control by it. Particular focus in all monitoring and evaluation mechanisms will be on minimising programmes' cost overruns and delays in delivering of the services.

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<sup>90</sup> COM(2010)308 of 14.6.2010, Impact assessment, accompanying document to the Communication of the European Commission on Action Plan on Global Navigation Satellite System (GNSS) Applications

If need be, assistance of external technical experts will be requested when monitoring the implementation of the programmes. On the basis of the results of the on-the-spot checks, the Commission will ensure that, if necessary, the scale or the conditions of allocation of the financial contribution originally approved and also the timetable for payments are adjusted.

The Commission will propose:

- a strategic framework including main actions, estimated budget and time-table necessary to meet the objectives of Galileo and EGNOS programmes at latest by 30 June 2014;
- an annual work programme translating the strategic framework into detailed measures and indicators to be proposed at latest by 15 December of the preceding year;
- an annual implementation report evaluating the fulfilment of the annual work programme to be proposed at latest by 15 March of the following year example;
- an interim evaluation of the Galileo and EGNOS programmes focusing on quantitative and qualitative results so far achieved by 30 June 2017 in due time for preparation of the next multi-annual financial framework.

Beyond these standard measures, the Commission in exercising its powers of political supervision over the Galileo and EGNOS programmes will strengthen the monitoring and evaluation mechanisms over the programme management entity by requesting detailed annual management plans and implementation reports as well as steering regular programme progress meetings and carrying out financial and technological audits.

In addition, the monitoring of the programmes should associate Member States for example by relying on their technical capabilities to provide input on technical monitoring of the programmes and on proposing key performance indicators against which the programmes will be evaluated.

Finally, in the day-to-day management, the Commission commits to propose a risk management mechanism and appropriate management tools to minimise the probability of programme cost overruns based on better cost estimation, taking stock of previous experience and actual system implementation.



## **9. ANNEXES**

**Annex I:** Overview of the Mid-term review

**Annex II:** Overview of the stakeholder consultations

**Annex III:** Studies and articles

**Annex IV:** Sector-specific impacts

**Annex V:** EU publications on GNSS

**Annex VI:** GNSS Market Monitoring and Forecasting Tool: Methodology

**Annex VII:** Performance maps

## **ANNEX I - OVERVIEW OF THE MID-TERM REVIEW OF THE EUROPEAN SATELLITE RADIO NAVIGATION PROGRAMMES (COM(2011) 5 FINAL)**

The European satellite radio navigation programmes are beyond the financial and technical capacity of individual Member States and therefore fall within the competence of the EU. In addition and especially given their security requirements, all the EU Member States have to be involved in them.

Since the reform of the programmes' governance in 2007 the Commission has recorded several successes: EGNOS has become operational and is performing excellently, and progress is being made with the deployment of Galileo. Parallel to this, several horizontal measures flanking the deployment of the infrastructure have been taken on the regulatory front, with regard to international aspects and in respect of future uses.

However, the programmes are now faced with fresh challenges arising from the materialisation of a number of risks which were previously identified by the Commission, and the organisation of the programmes must be further fine-tuned in order to increase their efficiency. The project has experienced cost overruns attributable in particular to the increased cost of the development phase, the increased price of the launchers, the lack of competition for the award of some packages and additional costs associated with the programme.

Furthermore, the economic situation of the EU and its Member States has led the Commission not to seek, up to now, the allocation of additional resources within the current multiannual financial framework, even though this is causing delays in completion of the full deployment of Galileo and an increase in overall costs.

A new basis for the work on the European satellite radio navigation programmes needs to be established so that progress can continue without compromising the objectives laid down by the European Parliament and the Council. Accordingly, the recommended approach envisages the present organisation being maintained and improved over at least 10 years, although it will have to evolve in line with the needs of the exploitation phase.

On the political front, several decisions still need to be taken. In a context in which Europe's economic and social progress is heavily dependent on mastering and using leading-edge technologies such as those relating to nuclear fusion, space, air traffic management and life sciences, it is important to reach decisions about the means, including budgetary means, of coping with the risks inherent in such technologies. Conclusions also need to be reached on the development of the EU budget and on how the risks are to be apportioned between the EU and its Member States. The decisions laying down the budgetary and financial principles governing the continuation of the European satellite radio navigation programmes will need to be taken in parallel with those concerning the governance framework. This must seek to make all the players more aware of their responsibilities, in order to ensure an orderly transition to future governance arrangements while at the same time enhancing control of the project and of its associated costs.

## ANNEX II - OVERVIEW OF THE STAKEHOLDER CONSULTATIONS

The European Commission participated at the following events in order to meet and discuss with a variety of stakeholders. The representatives of the Commission were invited as speakers to these events and the Commission was usually present with a stand.

<i>Stakeholder</i>	<i>Subject</i>	<i>When and how</i>
<b>Targeted consultations</b>		<b>In 2009, 2010 and 2011</b>
Member states, downstream industry, industry associations, ESA, GSA	<ul style="list-style-type: none"> <li>– Future of the Galileo and EGNOS programmes</li> <li>– Future services provision, marketing, costs evolution, risk analysis, future governance</li> </ul>	<p>In the frame of the Exploitation study (2009) which assessed the future evolution of the European GNSS programmes after 2013:</p> <ul style="list-style-type: none"> <li>– more than 50 interviews</li> <li>– 3 round tables</li> </ul>
Member states, ESA, GSA, selected industry experts	<ul style="list-style-type: none"> <li>– Problem definition</li> <li>– Assessment of policy options for completion of the Galileo system</li> <li>– Assessment of impacts</li> </ul>	<ul style="list-style-type: none"> <li>– Joint working group (2010) to define possible options and their impacts</li> <li>– Meeting on the impact of various policy options (2011)</li> <li>– Cost analysis (2010) [...]</li> </ul>
Member states, ESA, GSA	<ul style="list-style-type: none"> <li>– Problem definition</li> <li>– Assessment of policy options for future governance</li> <li>– Assessment of impacts</li> </ul>	<ul style="list-style-type: none"> <li>– Working group on future governance of the European GNSS programmes (2011)</li> </ul>
<b>Public consultations</b>		<b>In 2007 and 2009</b>
General public	<ul style="list-style-type: none"> <li>– Galileo programme</li> <li>– Satellite positioning systems</li> </ul>	Eurobarometer survey in June 2007
General public	<ul style="list-style-type: none"> <li>– Space activities</li> <li>– Independent positioning system for Europe</li> </ul>	Eurobarometer survey in July 2009
General public	<ul style="list-style-type: none"> <li>– Space programme</li> <li>– Importance of satellite based services</li> </ul>	Public consultation on a possible EU Space Programme in January - March 2011
<b>Conferences and workshops</b>		<b>Only the latest conferences in 2010 are listed</b>
Political stakeholders, navigation specialists, navigation researches,	<ul style="list-style-type: none"> <li>– Satellite navigation, current status quo and trends</li> </ul>	<ul style="list-style-type: none"> <li>– SAT Expo Europe 2010</li> <li>– Munich Satellite Summit 2010</li> </ul>

upstream industry representatives, downstream industry representatives	<ul style="list-style-type: none"> <li>– Satellite navigation applications</li> <li>– Satellite navigation research, FP7</li> </ul>	<ul style="list-style-type: none"> <li>– European Navigation Conference 2010</li> <li>– Galileo Applications days</li> <li>– Growing Galileo Info Day 2010</li> </ul>
Downstream industry focused on high precision applications	<ul style="list-style-type: none"> <li>– EGNOS for agriculture</li> </ul>	<ul style="list-style-type: none"> <li>– DLG Field Days</li> <li>– Intergeo</li> </ul>
Downstream industry focused on aviation applications	<ul style="list-style-type: none"> <li>– EGNOS for aviation</li> </ul>	<ul style="list-style-type: none"> <li>– Airport Exchange</li> <li>– ATC Global</li> <li>– Aero-Expo Friedrichshafen</li> <li>– EBACE</li> <li>– ILA Berlin</li> <li>– Farnborough Air Show</li> <li>– Europe Regional Airlines</li> <li>– SMAG</li> </ul>
Downstream industry focused on road applications	<ul style="list-style-type: none"> <li>– EGNOS for road transport</li> </ul>	<ul style="list-style-type: none"> <li>– ASECAP</li> </ul> <p>Transport Research Arena</p>

## ANNEX III - STUDIES AND ARTICLES

### Strategic input

- **Position papers from the user communities (2009, 2010):** International Civil Aviation Organisation (ICAO), the European Organisation for the Safety of Air Navigation (Eurocontrol) and COSPAS-SARSAT an intergovernmental organisation for search and rescue primarily on the requirements and expectations of users on the quality of services
- **Exploitation Study (2009),** Roland Berger Strategy Consultants, commissioned by the European Commission
- **Radio Frequency Interference Impact Assessment on Global Navigation Satellite Systems (2010),** Joint Research Centre, European Commission  
[http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/13508/1/reqno\\_jrc55767\\_radio\\_frequency\\_interference\\_impact\\_assessment\\_on\\_global\\_navigation\\_satellite\\_systems%5B1%5D.pdf](http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/13508/1/reqno_jrc55767_radio_frequency_interference_impact_assessment_on_global_navigation_satellite_systems%5B1%5D.pdf)

### Reliance on GPS

- **Global Navigation Space Systems: reliance and vulnerabilities (2010),** UK Royal Academy of Engineering  
[http://www.raeng.org.uk/news/publications/list/reports/Global\\_Navigation\\_Systems.pdf](http://www.raeng.org.uk/news/publications/list/reports/Global_Navigation_Systems.pdf)
- **Why Europe needs Galileo (2010),** European Space Agency  
[http://www.esa.int/esaNA/GGG0H750NDC\\_galileo\\_0.html](http://www.esa.int/esaNA/GGG0H750NDC_galileo_0.html)
- **GNSS and Critical Infrastructure of Electronic Communication (2010),** Research Institute of Posts and Telecommunications Slovak Republic, commissioned by the Ministry of Telecommunication in the Slovak Republic
- **Vulnerability assessment of the transportation infrastructure relying on the global positioning system (2001),** John A. Volpe National Transportation Systems Center, , commissioned by Office of the Assistant Secretary for Transportation Policy U.S. Department of Transportation  
<http://www.volpe.dot.gov/gps/gpsvuln.html>  
[http://ntl.bts.gov/lib/31000/31300/31379/17\\_2001\\_Volpe\\_GPS\\_Vulnerability\\_Study.pdf](http://ntl.bts.gov/lib/31000/31300/31379/17_2001_Volpe_GPS_Vulnerability_Study.pdf)
- **Global Positioning System Timing Criticality Assessment Preliminary Performance Results (2008),** John A. Volpe National Transportation Systems Center & Symmetricom, , 40th Annual Precise Time and Time Interval (PTTI) Meeting  
<http://www.pttimeeting.org/archivemeetings/2008papers/paper43.pdf>
- **How Vulnerable is GPS? (2001),** Avionics  
[http://www.aviationtoday.com/av/issue/feature/How-Vulnerable-is-GPS\\_12957.html](http://www.aviationtoday.com/av/issue/feature/How-Vulnerable-is-GPS_12957.html)

## ANNEX IV – SECTOR-SPECIFIC IMPACTS

### General economic reasoning

Present and future Global Navigation Satellite Systems provide a key enabling service for a rapidly growing number of business models and goods and services. GNSS could in future become as important and as crucial for the European economic fabric as are fossil fuels or telecommunication satellites today.

However, for this growth and modernisation potential to materialise, the provision of GNSS services must be available (24 hours a day and in each remote location) and accurate enough for the new business models and services. The risk in terms of security of supply or abuse of a dominant position should also be minimal.

The present situation cannot guaranteed this, as the market not only counts no independent European GNSS but is dominated by a non-European monopoly supplier with a specific policy agenda.

The services provided free of charge by the US-owned GPS has led to a mushrooming of new products and business models all over Europe and the developed economies. However, being a military project, the GPS comes with a severe security-of-supply risk for civil users. This obliges downstream users, as in the case of other products coming with a security-of-supply risk, to invest in risk-mitigation strategies.

In principle, the security-of-supply risk together with the abuse-of-a-dominant-position risk negatively impacts on the cost competitiveness of (European) business and clients. It requires indeed continuous investment in back-up technologies, which accounts for several billion euros per year<sup>91</sup>.

Second, these risks serve as a premium for incumbents on existing markets as they have built up the necessary old-fashioned knowledge through this hampering cost-reducing fiercer competition between incumbents and new market entrants.

Third, these risks stand as serious impediments to numerous new and cost-reducing business models along the whole value chain and across the whole economy that require (an absolute) security of supply – guarantee of service – and accuracy<sup>92</sup>. These opportunity costs resulting from the non-availability of an accurate, civil and reliable GNSS are difficult to estimate, as they relate to unobservable market developments. However, the market potential for such services could reach in the tune of several hundred billion euros per year<sup>93</sup>. If only a fraction of this was linked to cost savings for industry and its clients, such services could bring tens of billion euros of cost savings annually.

The extent to which the cost-saving potential of a more accurate and reliable European GNSS would improve the cost competitiveness of European industry depends to a large extent on the

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<sup>91</sup> It is true that providing such back-up technologies also serves as a basis for traditional business models and jobs (in Europe). However, the economic value of business models and jobs providing services that help to better deal with existing market failures is typically inferior to solutions where the market failure itself is remedied.

<sup>92</sup> Cf. auto-piloted landing of aircraft or auto-piloted road-transport (passenger cars or light and heavy duty vehicles) on long-distance motorway trips.

<sup>93</sup> [Please refer to the numerous studies quoted on this in other parts of the impact assessment.]

speed and quality of activating this cost-saving potential in Europe as compared to other regions of the world. Indeed, as GNSSs provide their services globally and without any regional discrimination, other economies also benefit from the cost-saving potential of a European GNSS for as long as its signal comes free of charge and without encryption.

Thus, the existence of a significant cost-reduction potential for the European industry does not automatically translate into an improvement of the international cost-competitiveness of the European industry. Such improvement requires great efforts from the European industry to actually go for this cost-reduction potential. But these efforts also need to be supported by a more holistic, deliberate and ambitious European innovation, modernisation and growth strategy: the Europe 2020 strategy. Concretely the European industry needs a credible assurance that the Galileo initiative has reached a point of no return and that exit from this ambitious project is no option. Without this planning security, European industry will not be in a position to fully go for harvesting the cost-reduction potential sketched above.





**Table 13: Sector-specific analysis of competitiveness impacts**

	<b>Cost / Price competitiveness</b>	<b>Innovative competitiveness</b>	<b>Commercial competitiveness</b>
<b>Upstream</b>	<p>With the full deployment of the satellite constellation, the European Space industry would have to buy larger quantities of components. Because of the better conditions granted to larger customers, its input costs would go down. This effect could be significant for this industry as it depends mainly on institutional markets</p> <p>The operations and renewals of full system should also bring economies of scale and increase productivity.</p> <ul style="list-style-type: none"> <li>– <b>(1-2)</b> high positive effect due to periodic renewal of the whole system</li> <li>– <b>(3-4)</b> lower positive effect, due to degraded system and associated development of the industry</li> <li>– <b>(5)</b> no effect on competitiveness</li> </ul>	<p>The build-up and operations of Galileo allows hundreds of European companies (ranging from multi-billion EUR conglomerates to specialised SMEs) to grow and invest more in R&amp;D. This should be a key competitive advantage for the space industry, which is characterised by long-term investments and realisations.</p> <p>If Galileo is terminated, the technology developed specifically for this programme might become useless or quickly obsolete (there was no off-the-shelf technology for services that only Galileo provides). European companies would then lose their early R&amp;D investment (sunk costs) linked to that specific technology. They might have to seek fresh risk capital and pay a premium for having invested in vain in Galileo.</p> <ul style="list-style-type: none"> <li>– <b>(1-2)</b> high positive effect due to high R&amp;D investments in the industry</li> <li>– <b>(3-4)</b> smaller positive effect due to degraded system and associated lower investments compared to baseline options</li> <li>– <b>(5)</b> negative effect, resulting from the likely loss of some of the early R&amp;D investment</li> </ul>	<p>Having contributed to the most advanced GNSS could be used to strengthen the image of EU satellite industry. Besides marketing benefits, it would provide additional references that could help securing future (public procurements) contracts.</p> <ul style="list-style-type: none"> <li>– <b>(1-2)</b> medium positive effect building on the "most advanced system" effect</li> <li>– <b>(3-4)</b> smaller positive effect</li> <li>– <b>(5)</b> no effect</li> </ul>

	Cost / Price competitiveness	Innovative competitiveness	Commercial competitiveness
Service providers	<p>The current structure of the industry is quite particular. There are only four entities operating or developing a GNSS (US, Russia, EU and Chinese public operators). The US and Russian operators offer location signals free of charge (open service), which is now considered by users communities as a vested right. The other operators intend to follow the same business model. In other words, there is no market price for this service. The policy option chosen on further implementation of the European satellite navigation programmes can therefore not affect the price competitiveness of this EU industry.</p> <p>EGNOS improves the open public service offered by the GPS. Similar regional augmentation systems are developed in Japan and India. These systems operate on a regional basis and don't compete on other regional markets. The policy option chosen will therefore not affect either the competitiveness of this GNSS sub-segment made of regional monopolies.</p> <p>The price competitiveness of the commercial services supplied by the GNSS industry is not threatened by substitute products as none can match the quality of its data. Development in the GNSS industry could even speed up structural adjustments by precipitating the decline of alternative technologies (such as the Real Time Kinematic System).</p> <p>Guaranteeing the long term development of the EU GNSS industry is likely to have a positive effect on its cost competitiveness. This would put it in a better position to negotiate with its suppliers. It would for instance not have to pay a premium for engineers kept on stand by upstream industries, in case a large GNSS order would come.</p> <ul style="list-style-type: none"> <li>– (1-2) limited positive effect on cost competitiveness; no effect on price competitiveness</li> <li>– (3-4) no effect on cost / price competitiveness</li> <li>– (5) not applicable (if the EU GNSS industry disappears, its competitiveness is no longer an issue)</li> </ul>	<p>Galileo system has a potential to bring major innovation regarding data accuracy, availability and integrity (security features guaranteeing that the data are authentic), to become a market differentiator and to provide a universal and global solution for legal value to positioning and timing.</p> <p>If the programme is terminated, the quality of the services provided by EGNOS might suffer in the long run, as EGNOS would have to continue to rely for a long time on the sole ageing GPS and Glonass systems.</p> <ul style="list-style-type: none"> <li>– (1-2) high positive effect due to framework conditions for new technological development the creation high investments and the capacity to provide improved data</li> <li>– (3-4) smaller positive effect due to degraded system and lower investments</li> <li>– (5) possible negative effect on EGNOS</li> </ul>	<p>Largely irrelevant considering the structure of this industry and the nature of this market</p>

	Cost / Price competitiveness	Innovative competitiveness	Commercial competitiveness
<b>Downstream</b>	<p>With reassurance on long term provision of Galileo signals, the applications industry will move more quickly to mass market stage in a number of cases, which would bring large economies of scale. Telecommunication operators in particular could play a key role in the up take of mass market services such as location based services or road transport related services. They are expected to pursue partnerships or acquisitions to guarantee a complete offer to end-users.</p> <p>The development of new products and services are also likely to increase economies of scope. Sectors such as telecommunications, electronics, ..., are indeed often able to cut their costs by providing a variety of products rather than specialising in a single output. The arrival of large players from other industries (cf. telecom operators) should increase competition and contribute to improve EU industry's price competitiveness. This would be especially the case where customers are very price-sensitive and face low switching costs (such as with Personal Navigation Devices).</p> <p>The number of EU competitors could increase in a number of niche markets with relatively low entry barriers, which would have a similar effect on price competitiveness, but to a limited extent (as niche markets' customers are often less price-sensitive, paying more attention to the performance of the product / service).</p> <p>Without a credible signal that the Galileo initiative has reached a point of no return and that exit from this ambitious project is no option, European industry will not be in a position to fully go for harvesting the cost-reduction potential sketched above. Options that don't fundamentally deal with the security of signal supply &amp; abuse-of-dominant-position risks would not result in significant competitiveness improvements.</p> <ul style="list-style-type: none"> <li>– (1-2) medium positive effect</li> <li>– (3-4) smaller positive effect</li> <li>– (5) no effect</li> </ul>	<p>The development of the EU GNSS industry and the provision of better GNSS signals will favour the emergence of a whole range of new added-value applications for end-users including:</p> <ul style="list-style-type: none"> <li>* LBS (Location Based Service, an information and entertainment service accessible through mobile phones);</li> <li>* ADAS (Advanced Driver Assistance System);</li> <li>* ISA (Intelligent Speed Adaptation);</li> <li>* Road user charging applications with more reliable authentication.</li> <li>* more accurate and continuous positioning for the aviation industry</li> </ul> <p>Innovation should also be based on increasing hybridisation with other technologies (e.g. WiFi, supporting the development of indoor positioning applications).</p> <p>European chipset manufacturers are expected to benefit from the direct involvement in the Galileo programme, gaining worldwide market share. This EU industry is indeed engaged in the miniaturisation of GNSS receivers, the reduction of power consumption, ..., increasing technological complexity in the receiver. The 7<sup>th</sup> FP<sup>94</sup> is supporting the development of these downstream activities. This could therefore secure "first-mover" advantages which are often very precious to preserve or increase its competitiveness. Here again, if the programme is terminated, the technology developed specifically for this Galileo based applications is likely to become useless or quickly obsolete (loss of sunk costs).</p> <ul style="list-style-type: none"> <li>– (1-2) medium positive effect due to high investments and associated high spill-over</li> <li>– (3-4) smaller positive effect due to degraded system and lower investments/ spill-over</li> <li>– (5) no or negative effect due to the loss of early R&amp;D investment</li> </ul>	<p>The GNSS programmes are not expected to have a major impact on the marketing, sales or after-sales processes of this industry, expect perhaps for the liability guarantee provided the EU GNSS industry.</p>

<sup>94</sup> The Seventh Framework Programme for research and technological development (FP7) is the Commission's main instrument for funding research over the period 2007 to 2013

	<b>Cost / Price competitiveness</b>	<b>Innovative competitiveness</b>	<b>Commercial competitiveness</b>
<b>End-users</b>	<p>The introduction of advanced GNSS-based applications in a growing number of sectors would lead to better allocation of resources, cost reduction and efficiency gains. These are for instance expected for</p> <ul style="list-style-type: none"> <li>* road user charging (thanks to the authentication service),</li> <li>* logistics fleet management</li> <li>* rail freight management (thanks to the continuity and availability of Galileo)</li> <li>* management of electricity grids</li> <li>* precision GNSS is expected to become a productivity tool in sectors such as construction, mining, agriculture</li> </ul> <p>This effect should be moderate rather than high because GPS already supplies similar services. Thanks to interoperability, Galileo would allow to enlarge the size of the relevant markets and the expected positive externalities.</p> <ul style="list-style-type: none"> <li>– <b>(1-2)</b> medium positive effect due to the improvement of the functioning of existing markets and higher productivity</li> <li>– <b>(3-4)</b> smaller effect</li> <li>– <b>(5)</b> no effect (as this option would deprive EU end-users from an opportunity)</li> </ul>	<p>EGNOS / Galileo-based applications provide many opportunities to European based firms in terms of product innovation and differentiation such as:</p> <ul style="list-style-type: none"> <li>* pay-per-use insurance (car insurance based on driving type, pattern and travelled kilometres)</li> <li>* tourist and rescue services</li> <li>* new techniques of law enforcement</li> </ul> <ul style="list-style-type: none"> <li>– <b>(1-2)</b> medium effect due to the process/product innovation and the creation of many new markets or segments</li> <li>– <b>(3-4)</b> smaller effect due to lesser technologic evolution</li> <li>– <b>(5)</b> no effect (as this option would deprive EU end-users from an opportunity)</li> </ul>	<p>Too many different (potential) end-users to draw general conclusions.</p>

## **Specific study on GNSS exploitation**

An extensive study<sup>95</sup> has been done to understand the market dynamics of sectors affected by the European GNSS Programmes and the impact of these programmes on their competitiveness.

First, a market segmentation has been done based on existing Commission's studies and external reports. Second, through several 'round-tables' with experts and end-users and numerous interviews with stakeholders throughout the value chain, a thorough market review has been carried out for the most important markets. Finally, an assessment of the demand by 2020 was performed.

Following sources were used during this study:

General studies:

Galilei (All markets), 2003  
ProDDAGE, (All markets), 2006  
ABI (All markets), 2007  
IDC (Location Based Services - LBS),e  
LEK (LBS, Road, Rail, Maritime, PRS), 2008  
LEK (Industry mapping), 2008  
Gartner, 2008  
Position Report, 2008  
Market Monitoring & Forecasting Tool, 2009  
JD Power Q1, 2009  
MMFT, 2009  
Euromonitor, 2008

Sector specific studies on applications:

AGILE (LBS), 2007  
GIANT (Aviation), 2006  
GIROADS (Road), 2005  
GRAIL (Rail), 2006  
MARUSE (Maritime), 2006  
Position One (High precision), 2008  
GIGA (Energy), 2005  
Harrison (Timing), 2007  
Pacific (PRS), 2007  
HELIOS (EGNOS Aviation), 2008  
HELIOS (LBS), 2008

Studies used for business modelling:

OVUM (GOC revenues), 2006  
OVUM (GOC revenues), 2001  
PWC (GOC Business plan), 2001  
PWC (Scenario update), 2007

The GNSS markets have been segmented in various axes, of which the 'type of usage' and the 'end user industry' are the most relevant. By adopting an application based approach, more than 100 applications have been identified and segmented according these axes. This segmentation provided eight macro independent segments with homogenous features to be deeply analyzed in the strategic assessment: Road segment, LBS segment, High accuracy segment, Aviation segment, Timing segment, Authentication segment, Robust positioning segment and Data broadcasting segment. These priority segments have been selected based on a set of quantitative and qualitative features, such as market attractiveness and public benefits.

As an example, the road segment strategic assessment is detailed hereunder.

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<sup>95</sup> Exploitation Study (2009), commissioned by the European Commission

## Market analysis for road applications

GNSS market size [€bn, worldwide]	Main demand drivers on PNT market																
<table border="1"> <caption>GNSS Market Size (€bn, worldwide)</caption> <thead> <tr> <th>Year</th> <th>Products</th> <th>Services</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>2010</td> <td>19,8</td> <td>2,3</td> <td>22,1</td> </tr> <tr> <td>2015</td> <td>22,0</td> <td>5,0</td> <td>27,0</td> </tr> <tr> <td>2020</td> <td>21,8</td> <td>8,1</td> <td>29,9</td> </tr> </tbody> </table> <p>CAGR 10-20            Services: +13,4%            Products: +1,0%</p>	Year	Products	Services	Total	2010	19,8	2,3	22,1	2015	22,0	5,0	27,0	2020	21,8	8,1	29,9	<ul style="list-style-type: none"> <li>• <b>Increasing demand</b> for location based services</li> <li>• Significant decrease in <b>navigation devices prices</b> (PNDs and In vehicle devices)</li> <li>• Improving <b>capabilities and performance of GNSS receivers</b> and related applications</li> <li>• Increasing awareness of <b>social, economic and environmental</b> consequences of <b>road traffic increase</b></li> <li>• On going national and <b>European regulations</b> (e-Safety, road tolling interoperability...)</li> </ul>
Year	Products	Services	Total														
2010	19,8	2,3	22,1														
2015	22,0	5,0	27,0														
2020	21,8	8,1	29,9														
Assessment of GNSS potential	Opportunities & threats for GNSS																
<ul style="list-style-type: none"> <li>• <b>Navigation applications</b> will continue their growth due to the <b>increasing penetration rate</b> of navigation devices and the development of <b>improved content</b></li> <li>• For <b>Road User Charging</b>, the GNSS solutions will be the preferred solution for only <b>very specific situations</b> (large networks with complex tolling policies). Current conceded highway operators are <b>unlikely to switch to the GNSS based solutions</b></li> <li>• Advance Driver Assistance Systems are <b>unlikely to develop before 2020</b> and GNSS solutions will not be the key technology for their implementation</li> </ul>	<ul style="list-style-type: none"> <li>• Opportunities:               <ul style="list-style-type: none"> <li>– <b>Regulatory evolutions</b> could enable the development of some applications:                   <ul style="list-style-type: none"> <li>- Implementation of the interoperability of toll systems within Europe (directive 2004/52)</li> <li>- Implementation of e-Safety European regulation</li> </ul> </li> <li>– Multiplication of <b>tenders for electronic toll collection</b> systems in Europe</li> </ul> </li> <li>• Threats:               <ul style="list-style-type: none"> <li>– Well established <b>competitive technologies</b> on promising applications (toll collect, e-call, ADAS)</li> <li>– <b>Unclear business models</b> linked to future "public enabled" applications (e.g. e-call business model)</li> </ul> </li> </ul>																

### 1. Market definition

GNSS road transport is a wide-ranging and complex market segment combining mass-market applications (in-vehicle navigation) and commercial applications. Moreover, GNSS is an enabling technology for intelligent transport systems (ITS) including road user charging.

The market, as perceived by the end user, is definitely wider than that of services provided through GNSS solutions. In a number of instances, the consumer opts not for a technology but for a complete service that meets his or her requirements, not necessarily based on GNSS. In all case, GNSS road transport applications require:

- an adequate signal or combination of signals from the satellite constellation and the corresponding ground segment,
- a device, in-built by the vehicle manufacturer or portable mobile handset and
- a commercial or public entity with the required facilities (ground infrastructure, reliable and updated content sources, etc.) and entrepreneurial capacity to deliver and manage the service

### 2. Demand drivers and trends

#### *Demand drivers*

The following factors will foster the take-up of GNSS-based road applications:

- the necessity for public authorities and road users to avoid traffic congestion;
- the increasingly widening policy amongst municipalities aiming limiting the use of cars in urban areas for public health and environmental reasons;
- safety concerns (emergency calls, ADAS, etc),
- eco-driving and eco-routing to reduce the CO2 emissions

- a continuous reduction in the prices of car receivers and more integrated services available (e.g. traffic information, weather forecast, increase map-updating, etc);
- the growing processing power of handsets;
- trend towards the systematic inclusion by the automotive industry of GNSS receivers in new cars;
- the gradual entry into service of intelligent transport systems aiming at for example a better integration of the overall logistic chain or more adaptable public transport management services.

The factors of risk that could hamper the development of GNSS-based road services are:

- insufficiently agreed standards, that may lead to a vertical integration between services providers and receivers manufacturers and thus to a decreased competition on the market;
- the absence today of technical solution ensuring the authentication of a position produced by a GNSS receiver;
- Inconstencies in regulatory initiatives concerned with positioning.

### *Market trends*

Personal Navigation Devices have been the main driver for the car navigation market. The sales of affordable, feature-rich, and easy to use PNDs have grown more than 100% in recent years, with companies such as Garmin, TomTom, and Mio dominating the market. Features such as speech recognition, multimedia playback, and digital cameras have recently become available on high-end PND devices.

Factory-installed navigation systems and aftermarket navigation solutions have been much less popular due to high prices and lack of portability. It is however expected that factory-installed systems sales will continue to grow as it is offered on more vehicles at lower prices.

Car navigation devices will face increasing competition from converged handset-based software solutions. Off-board handset-based navigation will be offered by cellular carriers guaranteeing always up-to-date maps, traffic, and content. Positioning represents a relatively new field of development and business, with presumably a large potential.

At the beginning, the market was developed thanks to the introduction of navigation devices by vehicles manufacturers in upper range cars and trucks. However, in the recent years, major growth has been fuelled by availability of inexpensive personal navigation devices. The market for installed in-vehicle navigation systems has remained largely stagnant over the last ten years. Some experts point out that there has been low responsiveness in car makers to GNSS-related innovation lag compared to vehicle adapted personal navigation device (e.g. Tom-Tom or Garmin).

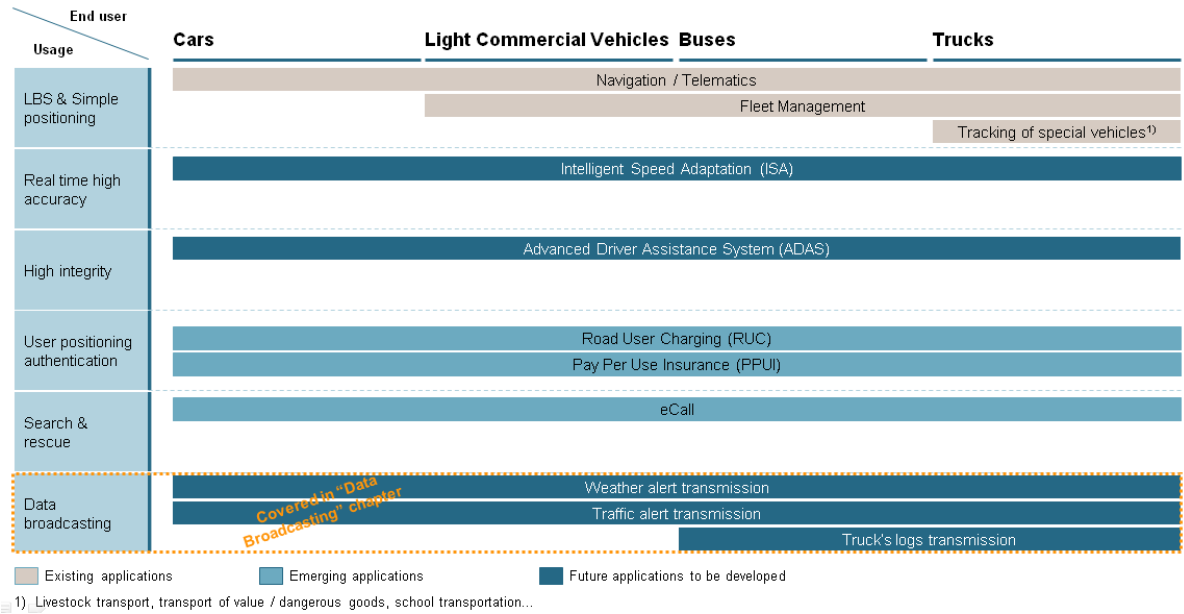
This market nevertheless evolves from the pioneering phase to mass market penetration. For example, in-vehicle navigation is quickly gaining market share under the push of hand portable device based solutions. Other applications like road use charging and intelligent speed assistance could become widespread in relatively short time. As of 2008, the market for GNSS-based services was growing more rapidly than the number of new vehicles in Europe and North America.

When looking at the potential of satellite positioning in these target markets, the general outlook is that satellite positioning will have a more and more relevant role in road transport, both in mass-market and niche market applications. GPS is already widely used in in-vehicle navigation, both in embedded system and system based on nomadic devices and is set to become a ubiquitous enabling technology for ITS. Currently U.S. Wide Area Augmentation

System (WAAS) and EGNOS enabled receivers are beginning to become the default GPS receiver bringing improvements in accuracy and making the integrity signal available for applications involving user dependence, licensing and safety.

Finally, eleven PNT applications have been identified so far in the Road segment, 6 been already existing or emerging in the market. This is illustrated in Figure 6.

**Figure 6: Review of identified positioning, navigation and timing applications in Road transport market**



**3. Current market size and estimation of potential**

*Methodology to measure market size*

Revenues for operators marketing road application products or services will derive from two sources – the sale of GNSS enabled receivers, with one-off income for the seller, and the provision of services related to specific value added components, to content, to updating functions, paid in the form of irregular fees (e.g. depending on usage) or of subscriptions. Hence, the total market size will, for each application, be a combination of sales of receivers and services at a certain price level, applied to a more or less expanded population of vehicles.

*Estimates of market size*

For the road segment, forecasts differ significantly from a study to another although on similar perimeters. For example, in the horizon 2020, estimated revenues<sup>96</sup> vary between € 70 and € 120 billion in the respectively worst and best case scenarios<sup>97</sup>. Under the most

<sup>96</sup> In terms of sales figures for equipment and related accessories (software updates, maps, etc)  
<sup>97</sup> Cf. Proddage (2006), Helios (2008), LEK, ABI - Revenues are “gross” revenues based upon the whole price paid by users to acquire an application. They are therefore a measure of overall business generated by GNSS rather than a measure of GNSS specific business

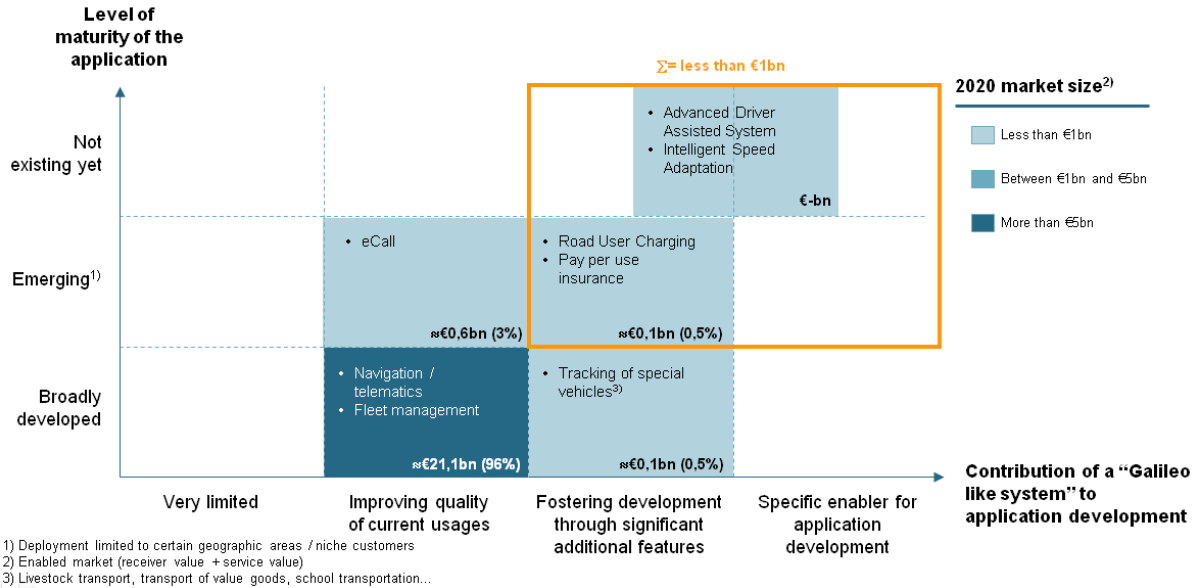


conservative existing assumptions, the value generated by Road applications would approach € 50 billion by the beginning of the 2020s<sup>98</sup>.

This study has reviewed the assumptions developed under previous studies. This review has led to a more careful scenario as to the total number of vehicles during the next decades, taking into account a post-crisis environment in which demand will grow at a reduced pace, in a more general context of depletion of fossil resources and increasing concerns on greenhouse gases emissions<sup>99</sup>.

This revised assumption leads to an even more conservative set of predictions. The total GNSS market size for road accounts for €30bn by 2020. The GNSS product enabled market size ranges from €16bn to €34bn, with a conservative scenario accounting for €22bn as shown in Figure 7.

**Figure 7: Assessment of Galileo’s impact on Road Segment – Focus on product enabled market**



**4. Detailed review of the main road segment applications**

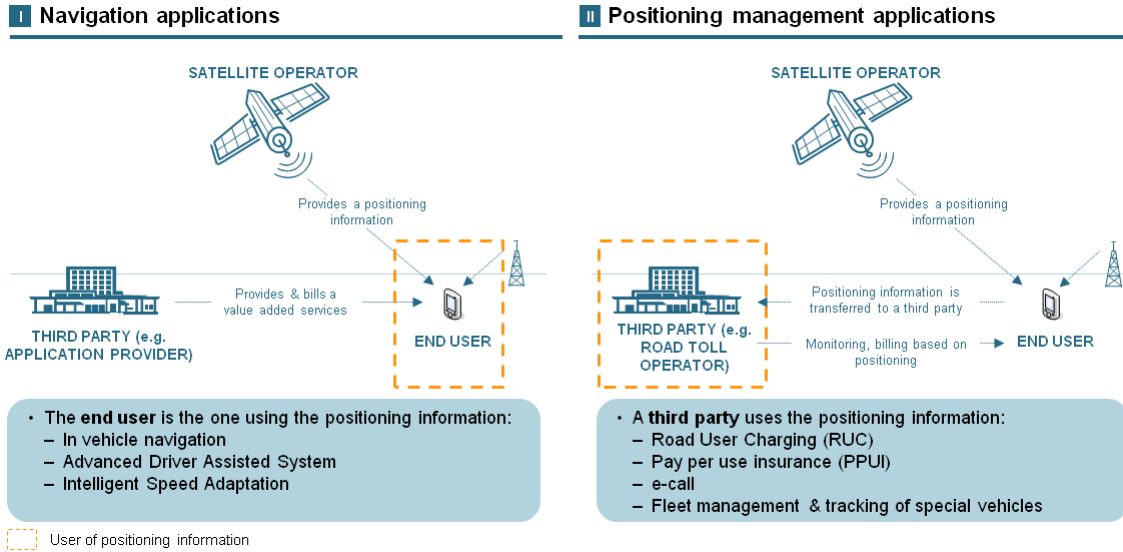
Among all existing or potential applications, we propose to examine in a more detailed manner the most promising applications, combining both a large market size (and thus presumably accounting for indirect benefits) and significant direct revenue potential for the prospective GALILEO Operating Structure (direct benefits).

The navigation applications and positioning management applications will be detailed hereunder. In Figure 8 the typology of these kind of applications is explained and in Figure 9 the value chain is detailed.

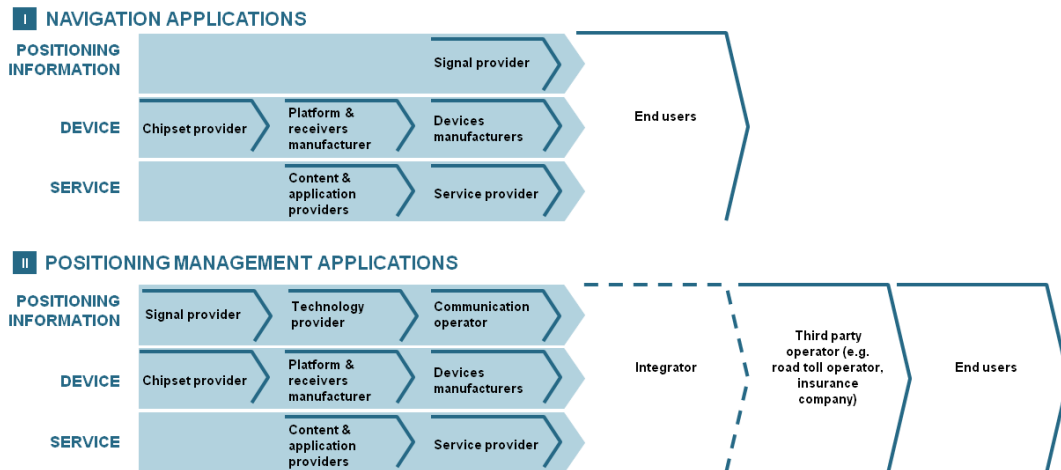
<sup>98</sup> Cf. Based on a review of underlying assumptions in the various estimates. The forecast focuses on long trends; it goes beyond the current economic context, assuming moderate growth rates of the overall number of vehicles in service.

<sup>99</sup> By doing so, this study, contrary to previous ones performed in the early years 2000, has considered it impossible for the existing long term demand trends to continue without any significant alteration.

**Figure 8: Typology of road applications**



**Figure 9: Typical value chain by typology of application**



*I. Navigation applications*

Best itinerary services

Two different types of applications should be distinguished. In basic systems, navigation is totally managed by an onboard unit including a digital map and will limit itself to providing the best theoretical itinerary between two points. In the most sophisticated devices, the real-time traffic information provided by a service operator will help the onboard device to optimize its proposal to the driver according to criteria which will be more generally the time spent. The second application (the real-time one) is the most promising for the future.

Overall, the use of an onboard GNSS terminal provides vehicle location and time that facilitates the provision of services aimed at improving the safety, comfort and effectiveness of road travelling using two-way data and voice communications between a service provider and an end-user in a vehicle. Typical examples of commercial services to vehicle users are route navigation (static or dynamic) or theft alarm and recovery. Many of these services are provided on a subscription basis.

Telematics is a combination of telecommunications and network computing. More precisely, in the automotive sector, telematics consists of information services delivered to a remote in-vehicle device over a wireless communications network. Telematics systems are already used

to deliver valuable data for a variety of applications and are expected to grow substantially in the future.

Penetration rates should continue to increase, the presence of on-board units, either built-in or portable, increasingly becoming a standard feature of a vast majority of new vehicles as the price for terminals is likely to decrease over time. Navigation applications are generally based on open service signals only. The improvement in accuracy will result, if needed, from the use by the terminal of more than one constellation, including Galileo or of EGNOS.

ADAS (Advanced Driver Assistance Services)

Advanced driver assistance systems (hereafter ADAS) are intended to increase car safety and more generally road safety by helping the driver with vehicle control and thus avoiding accidents caused by human errors. ADAS take into account not just the driver and the vehicle but also the immediate driving environment. By receiving information from outside of the vehicle, the systems are able to assess the risk of an accident occurring. Then, the systems can either warn the driver so as to take avoidance steps or can automatically initiate the appropriate actions. An indicative list of ADAS classified on their level of autonomy or integration in an cooperative ITS environment is provided in Table x.

<b>Advanced Driver Assistance Services</b>	
<b>Autonomous</b>	<b>Cooperative</b>
Cruise Control (CC)	Cooperative ACC
Adaptive Cruise Control (ACC)	Intelligent Speed Adaptation
Lane departure warning/lane keeping assistant	Curve speed warning
Collision Avoidance	Cooperative intersection collision avoidance
Emergency braking systems	Local hazard warning
Electronic Stability Programme (ESP)	Vehicle platooning
Driver condition warning	Autonomous driving
Pre-crash protection of vulnerable road users	In-car traffic information / data collection
Lane Change Assistant	Post crash warning

Most of the aforementioned ADAS require vehicle positioning mechanisms and thus involve the use of an onboard GNSS terminal. In particular, GNSS is critical for ADAS co-operative systems where assistance is provided from roadways and/or from other vehicles, requiring the exchange of Position Velocity Time (PVT) information. Of course, ADAS requires information not only from a GNSS receiver but also from other onboard sensors, vehicle radars and actuators or information receive by other vehicles or the roadside ITS infrastructure. Location is one of the parameters needed, especially as it allows map matching with the memory of the system. Thus high accuracy (sub-metre), availability and integrity with short time to alarm (in the order of 1s) are required.

Considering that ADAS is a safety critical application, the certification of Galileo and of the ADAS equipment will be needed as is the case in the aviation or marine domains.

The term ADAS covers a variety of applications differing from the environment in which they are relevant, from the functionalities offered, from the degree of automation and symmetrically the level of autonomy left to the driver in the vehicle. This family of applications involves issues related to liability in case of malfunctioning of the system resulting in damages to the driver, to the passengers or freight and/or to third parties.

ADAS is considered by the large majority of experts and stakeholders to materialise in the long term only as it is still necessary to achieve significant progress in market awareness and to overcome strong cultural and psychological impediments.

The main obstacles today to the advent of ADAS are:

- ADAS requires the simultaneous availability of a number of different technologies, probably both embedded in the vehicle and in the infrastructure. These technologies are in some cases still under development and in some other cases their combination is not yet fully mastered.
- ADAS requires the availability of a number of infrastructures and of their regular update. A typical example is maps, which need to fulfil certain quality requirements, include a number of additional attributes compared to today's situation and guarantee being up-to-date to ensure safe operations. This is clearly not yet achieved on a large coverage basis.
- The mass-market introduction of ADAS requires solving a number of regulatory issues like, for instance, certification procedures as explained above, standard and interoperability as well as liability in case of malfunctioning; it also assumes a readiness by end users to entirely trust devices and applications supposed to replace, to a significant extent, their own intelligence and judgment.
- The cost of ADAS is still prohibitive for introduction on lower segment vehicles and user willingness to pay seems to go more in the direction of comfort systems rather than safety systems.

In conclusion, ADAS is still in its infancy compared to the penetration rates that have been achieved by the navigation systems. Contrary to the navigation market, where firm trends can already be perceived, there is currently no serious hint of what market take-up would look like. It is likely that it will be resulting by the combination of regulation, vehicle makers' differentiation strategies and reaction by *customers*.

## II. *Positioning management applications*

### eCall – Emergency Call Services

eCall stands for "automatic in-vehicle emergency call system". The eCall system is based on either the automatic detection of an accident or a manual eCall made by pushing a button. In both cases a voice communication is opened to the emergency centre after a small delay due to the automatic transmission of the Minimum Set of Data (MSD), including time-stamp, vehicle location and propulsion type of the vehicle.

The data of the vehicle location and direction at the time of the accident is obtained from the GNSS receiver. Today, by means of GPS, the location can be determined to within 10 metres using absolute positioning. In the future, Galileo will allow the positioning be even more precise, i.e. within one metre.

The use of such accuracy will for instance allow a motorway operator to discriminate on which side of the road the accident occurred, which is an important information to drive the nearest rescue team to the place and to warn drivers going in the same direction.

The receiving of an automatic emergency call does not alter the process at the emergency centre but the procedure is the same as with a usual emergency call. The goal is that the data packets transmitted by the eCall system can give the Public Safety Answering Point (PSAP) operator all the necessary information needed for the placement of an emergency call. After the eCall device detects an accident it transmits to the most appropriate PSAP the MSD containing the following information:

- Timestamp
- Vehicle location and direction (provided by GNSS)
- Vehicle propulsion storage type
- Number of passengers (if available)

The implementation of the eCall service requires equipping vehicles with eCall in-vehicle systems. It requires also the transmission of the eCalls by the Mobile Network Operators (MNOs) and the upgrade of the PSAPs.

The harmonised implementation of an interoperable EU-wide eCall service in the EU has been in the agenda of the European Commission since 2005 and has become now a priority action for the improvement of road safety and the deployment of ITS in Europe.

All major stakeholders directly affected by eCall are supporting its deployment under the condition that the implementation will be undertaken in parallel by all actors (mainly OEMs, MNOs and PSAPs). More than 80% of the people responding to the public consultation find the eCall system useful and they would like their vehicle to be equipped with eCall.

Numerous studies on eCall have shown that the system can potentially avoid around 4% of the road fatalities per year in Europe and reduce the severity of injuries by a factor around 6%. eCall can also have a significant impact on the reduction of the congestion caused by the traffic accidents and thus the overall congestion of the European roads.

A great variety of GNSS applications can today be found in transport and this is expected to significantly increase. Just to name two, traffic management is improved through GNSS road tolling and real-time travel information is provided directly to the driver to avoid congested areas. The introduction of the eCall system in the vehicles could also contribute significantly to the deployment of a European market for GNSS applications, widely promoted by the European Commission which has recently (June 2010) adopted an Action Plan for the development of the applications of GNSS. Intelligent Transport System for Road is one of the main focus of this Action Plan.

#### *Finnish Market research*

The most complete research on the impacts of an automatic emergency call system (eCall) on accident consequences has been carried out in Finland<sup>100</sup>. The key evaluation results of that study indicate that the eCall system could very probably have prevented 4.7% of the fatalities in accidents involving motor-vehicle occupants. In the accidents involving fatal unprotected road user, however, the system could probably have prevented no fatality. In all, eCall system was estimated to be able to reduce 5–10% of motor vehicle fatalities and 4–8% of all road fatalities in Finland.

The results showed that, in most accidents involving motor-vehicle occupants (82%), the emergency call had been made within five minutes of the accident. However, in 14% of the

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<sup>100</sup> The technical report is published in Finnish (Virtanen 2005)

cases the emergency call had been made 5–30 minutes after the accident and in approximately 4% of the cases more than 30 minutes after the accident. In the accidents involving fatal unprotected road user, the delays were slightly shorter. The benefit-cost ratio of the eCall system examined in this study was estimated to be in the range of 0.5–2.3. The benefit-cost ratio would have been higher if the indirect benefits of the eCall system could have been taken into consideration.

Based on the main findings of this study, the eCall system was recommended for immediate and widespread implementation in Finland. The study also indicated a need for developing statistics on severely injured accident casualties.

The consumers are also interested in emergency call systems. An interview of almost 100 drivers made in March 2004 revealed that an automatic emergency call system is the second most required accessory or service for a vehicle. Only anti-lock brakes were deemed more essential. The necessity of an automatic emergency call system compared to other equipment was not affected either by the annual kilometres driven or whether the driver drove mainly on rural roads or in towns. One third of the drivers were willing to pay 100-299 euros for eCall equipment and one third 500-999 euros. (Ministry of Transport and Communications of Finland 2004).

### Road user charging (RUC)

The main objective of road user charging based on GNSS solutions is linked to policies developed by the Member States to fight congestion, finance the maintenance of the roads, ... Most systems are based on electronic means to speed up the toll collection process,.

Road user charging has often been presented as a sub-market with a potentially high potential, as interest of governments is increasing for reducing traffic congestion and its collateral damages to the economy and the environment, while improving safety for road users, whereas motorway operators logically seek to improve the cost-effectiveness of their toll collection systems.

To date, road user charging is applied in Europe almost exclusively on motorways, or if extended to a larger network, it is limited to certain categories of vehicles like trucks (Germany, Austria, Slovakia, and Czech Republic). Usage in urban environments is so far only in operation for a very limited downtown area of large conurbations, like London, Stockholm and Milan, but could gain momentum with growing concerns of public authorities for avoidance of traffic nuisance in urban areas.

Growing congestion problems and greening of transport initiatives clearly represent the main opportunity to foster GNSS-based RUC systems in the EU. This opportunity is hampered today because of market fragmentation of the industry, with lack of common standards, patchwork of different systems applying in different geographical areas and lack or disparity of regulation. The co-existence of European RUC systems based on different technologies raises the problem of interoperability across different countries.

So far, progress of electronic (or 'virtual gate') tolling fee collection has been slow, in the absence of legal obligations, despite advertising efforts on the side of operators. It is estimated that no more than **6%** of European vehicles are equipped with adequate devices allowing electronic fee collection.

Currently, the technology used in most national systems is a non-GNSS microwave technology called 'Dedicated Short-Range Communications' (DSRC). Another wireless

technology used in RUC is a combination of GNSS and GSM-GPRS. The first European satellite-based toll collection system is Toll Collect in Germany.

Non GNSS based solutions seem to be most appropriate for motorways, and will probably remain so, except if the legal and technical conditions of use of GNSS for tolling allow the operators to limit the percentage of fraud to the level they have with competing technologies like DSRC.

GNSS based solutions are technically more appropriate for dense networks of roads and streets, especially as they do not require huge investments in roadside equipment. GNSS-based solutions offer advantages in the following situations:

- dense and complicated networks of tolled roads with no planned tolling facility (toll plazas, gantries...)
- widespread tolling (e.g. most highways, and not only motorways, become subject to tolling),
- possible interoperability with networks and countries already equipped with GNSS tolling mechanisms.

In general, a GNSS-based road tolling implies huge sunk or stranded cost at the beginning<sup>101</sup> (the German Toll Collect cost more than 3.4 billion to the German authorities). However, alternative systems are expensive too. A comparative cost-benefit analysis covering all relevant cost-factors and the cycle of economic life (obsolescence) of the alternative solutions could justify GNSS-based system for motorways usage, e.g. at pan-European level.

Beside these factors related to the cost of infrastructure, a major differentiator in favour of Galileo should be in its value added, i.e. its integrity and authentication functionalities, which might help reducing fraud possibilities. However, the assessment of the operators faced with technology choices will result from a balance of the advantages and shortcomings of each solution, each of them being appraised in a specific national environment determining the structure of the road network and the ownership of the roads<sup>102</sup>.

It is not absolutely certain that the need to reduce collection evasion is so high as to lead toll collecting operators to give preference to a technical solution that, in some cases, will appear as less cost effective than other available technologies. At first sight, there is no clear-cut or compelling reason justifying a systematic resort to GNSS based solutions, each case being assessed on its own merits in the light of a specific context.

Legislative initiatives in favour of road tolling would give a boost to penetration of virtual road tolling. It would be justified by the necessity to increase the fluidity of road traffic<sup>103</sup>, especially for trucks, and by environmental concerns. The extension of tolling for environmental purposes to large parts of national networks<sup>104</sup>, far beyond the mere motorways would clearly favour GNSS. In addition, achieving the European initiative in favour of interoperability should incite to use the most widespread system, or that of the leading EU economy.

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<sup>101</sup> Sunk costs are start up costs that cannot be recovered if the business project fails.

<sup>102</sup> The fragmentation of ownership between hundreds and even thousands of public authorities will certainly be a major impediment to the emergence of unified tolling schemes even at national level, not to speak from the European level. The adoption of GNSS at a large scale would definitely be easier in the case of motorways exploited by a limited number of operators. Market penetration will thus probably be slow for highways of the secondary network.

<sup>103</sup> The fact that Germany was an early adopter of GNSS based solutions could contribute to foster this technology, given the central place of this Member State in the European Union.

<sup>104</sup> Cf. Commission's Communication on the greening of transport.

However, under the principle of technological and thus market neutrality, no EC legislation can clearly impose the resort to GNSS solutions, provided that the objectives (e.g. a single invoice) are met. Directive 2004/52/EC, in this regard, consistent with this principle, mentions GNSS-based solutions among other alternative possibilities and thus gives no particular support to those solutions. Moreover, since 2004, very limited progress has been seen on this field and no major legislative breakthrough can be foreseen in the near future to boost market take-off.

Against this background, the available forecasts need to be treated with caution<sup>105</sup>.

### Tracking of special vehicles

Commercial and consumer vehicle tracking can also be applied for fleet management, workforce management, stolen vehicle recovery and insurance. Vehicle-tracking devices consist of a location and communication module.

In Europe, uptake has been slowed up until now due to a fragmented market, lack of end-to-end services, complexity, the absence of standards, and privacy issues. However, uptake is expected to accelerate if, for example fragmentation and lack of harmonisation problems at European level are addressed in the years to come.

Most GPS vendors are only active in a limited number of market segments, such as in-vehicle navigation and vehicle tracking. Garmin and Trimble are the main vendors that have designed products for a wide range of applications and segments. Garmin is active in a large number of consumer segments such as in-vehicle navigation, marine, recreational, aviation, animal tracking, and communication.

Trimble is the main vendor of industrial applications such as machine control, surveying and mapping, vehicle tracking, timing, and military. Both companies have been very successful in leveraging their broad engineering and manufacturing skills, including GPS, radio, laser, and sonar across many applications and segments.

It is expected that with the launch of additional GNSS systems such as GALILEO, new applications such as tourism, culture, and train-tracking will emerge, as companies are exploring new opportunities to capitalize on the increased precision and reliability of GNSS-positioning.

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<sup>105</sup> They vary, according to different studies, between 830 M€ and 1.2 Bn € in 2025.



## ANNEX V - EU PUBLICATIONS ON GNSS

### Regulations

2010 – **Regulation (EU) No 912/2010** of the European Parliament and of the Council of 22 September 2010 setting up the European GNSS Agency, repealing Council Regulation (EC) N° 1321/2004 on the establishment of structures for the management of the European Satellite Radio Navigation programmes and amending Regulation (EC) No 683/2008 of the European Parliament and the Council

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:276:0011:0021:EN:PDF>

2008 – **Regulation (EC) No 683/2008** of the European Parliament and of the Council of 9 July 2008 on the further implementation of the European satellite navigation programmes (EGNOS and Galileo)

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:196:0001:0011:EN:PDF>

2006 – **Council Regulation (EC) No 1942/2006** of 12 December 2006 amending Regulation (EC) No 1321/2004 on the establishment of structures for the management of the European satellite radio-navigation programmes

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:367:0018:0020:EN:PDF>

2006 – **Council Regulation (EC) No 1943/2006** of 12 December 2006 amending Regulation (EC) No 876/2002 setting up the Galileo Joint Undertaking

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:367:0021:0022:EN:PDF>

2004 – **Council Regulation (EC) 1321/2004** on the establishment of structures for the management of the European satellite radio-navigation programmes

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:246:0001:0009:EN:PDF>

2002 – **Council Regulation (EC) 876/2002** setting up the Galileo Joint Undertaking

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:138:0001:0008:EN:PDF>

### Council resolutions and decisions

2011 – **Council conclusions on the Report from the Commission to the European Parliament and the Council Mid-term review of the European satellite radio navigation programmes**, 3080th Transport, Telecommunications and Energy Council meeting Brussels, 31 March 2011

<http://register.consilium.europa.eu/pdf/en/11/st08/st08395.en11.pdf>

2007 – **Council Conclusions on launching the European Global Navigation Satellite System Programmes**, 2835th Transport, Telecommunications and Energy Council meeting , Brussels, 29-30 November/3 December 2007

<http://register.consilium.europa.eu/pdf/en/07/st15/st15891.en07.pdf>

2007 – **Council Resolution on Global Navigation Satellite System (GALILEO): state of play and future options**, 2805th Transport, Telecommunications and Energy Council meeting, Luxembourg, 6-8 June 2007 /1 June 2007

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2006 – **Council Conclusions on the progress of the GALILEO programme** - 2754th Transport, Telecommunications and Energy Council meeting Luxembourg, 12 October 2006

<http://register.consilium.europa.eu/pdf/en/06/st13/st13496.en06.pdf>

2004 – **Council Decision 2004/578/EC** of 29 April 2004 on the conclusion of the Framework Agreement between the European Community and the European Space Agency

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:261:0063:0063:EN:PDF>

2004 – **Council Joint Action 2004/552/CFSP** of 12 July 2004 on aspects of the operation of the European satellite radio-navigation system affecting the security of the European Union

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:246:0030:0031:EN:PDF>

2004 – **Council Conclusions on the European Global Navigation Satellite System (GNSS)** - Transport, Telecommunications and Energy Council meeting, 11 June 2004

<http://register.consilium.europa.eu/pdf/en/04/st10/st10507.en04.pdf>

2002 – **Council Conclusions on Galileo programme** - 2472th Transport, Telecommunications and Energy Council meeting, 5-6 December 2002

<http://register.consilium.europa.eu/pdf/en/02/st15/st15121.en02.pdf>

2001 – **Council Resolution of 5 April 2001 on Galileo**

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1998 – **Council Decision 98/434/EC** of 18 June 1998 on the agreement between the European Community, the European Space Agency and the European Organisation for the Safety of Air Navigation concerning a European contribution to the development of a Global Navigation Satellite System (GNSS) [Official Journal L 194 of 10.7.1998]

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31998D0434:EN:HTML>

## **Parliament resolutions**

2007 – **European Parliament resolution of 26 April 2007** on the Galileo concession contract negotiations

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2008:074E:0752:0753:EN:PDF>

## **Commission communication, decisions and work programmes**

### *Commission communication*

2011 – **Communication from the Commission n° 5** to the European Parliament and the Council on the mid-term review of the European satellite radio navigation programmes

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0005:FIN:EN:PDF>

2010 – **Communication from the Commission n° 308** to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions on the Action Plan on GNSS applications

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0308:FIN:EN:PDF>

2009 – **Communication from the Commission n° 302** to the European Parliament and the Council on the implementation of the GNSS programmes and on future challenges

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0302:FIN:EN:PDF>

2007 – **Communication from the Commission n° 534** to the European Parliament and the Council on progressing Galileo: re-profiling the European GNSS programmes

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0534:FIN:EN:PDF>

2007 – **Communication from the Commission n° 261** to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on Galileo at a cross-road: the implementation of the European GNSS programmes

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2007:256:0073:0075:EN:PDF>

2006 – **Communication from the Commission n° 272** to the Council and the European Parliament: Taking stock of the Galileo programme

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0272:FIN:EN:PDF>

2006 – **Communication from the Commission n° 769**: Green Paper of 12 December 2006 on Satellite Navigation Applications

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0769:FIN:EN:PDF>

2004 – **Communication from the Commission n° 636**: Moving to the deployment and operational phases of the European satellite radio navigation programme

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2004:0636:FIN:EN:PDF>

2004 – **Communication from the Commission n° 112** to the European Parliament and the Council - Progress report on the Galileo research programme as at the beginning of 2004

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2004:0112:FIN:EN:PDF>

2002 – **Communication from the Commission n° 123** to the European Parliament and the Council - Integration of the EGNOS programme in the Galileo programme

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2003:0123:FIN:EN:PDF>

2002 – **Communication from the Commission n° 518** to the European Parliament and the Council - State of progress of the Galileo programme

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2002:248:0002:0022:EN:PDF>

2000 – **Communication from the Commission n° 750** to the European Parliament and the Council on Galileo

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2000:0750:FIN:EN:PDF>

1999 – **Communication from the Commission n° 54** - Involving Europe in a new generation of satellite navigation services

<http://eur-lex.europa.eu/Notice.do?val=334306:cs&lang=en&list=334306:cs.&pos=1&page=1&nbl=1&pgs=10&hwords>

2008 - **Report from the Commission COM/2009/0302** to the European Parliament and the Council on the implementation of the GNSS programmes and on future challenges pursuant to Article 22 of Regulation (EC) No 683/2008

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0302:FIN:EN:PDF>

*Commission decisions*

2010 – **Commission Decision of 6 October 2010** setting up the group of experts on the mission evolution of the European navigation satellite systems, the ‘Mission Evolution Advisory Group’

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:271:0002:0003:EN:PDF>

2009 – **Commission Decision of 20 April 2009** establishing an expert group on the security of the European GNSS systems

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:101:0022:0024:EN:PDF>

2008 - **Commission Decision C(2008)8378** of 12 December 2008 adopting the Strategic Framework of the GNSS Programmes

#### *Commission work programmes*

2010 – **Commission Decision C(2010)1617** of 23 March 2010 concerning the adoption of a financing decision for 2010 in the framework of the European satellite radio-navigation programmes (EGNOS and Galileo)

2009 – **Commission Decision C(2009)2227** of 3 March 2009 adopting the 2009 Work Programme of the European Satellite Radio-navigation Programmes

2008 – **Commission Decision C(2008)8371** of 12 December 2008 adopting the 2008 Work Programme of the European satellite radio-navigation programmes (EGNOS and Galileo)

#### **International agreements**

##### *China*

2003 – Proposal for a Council Decision on the signing of the Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) - GALILEO between the European Community and its Member States and the People's Republic of China

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2003:0578:FIN:EN:PDF>

##### *Israel*

2004 – Proposal for a Council Decision on the signing of the Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) between the European Community and its Member States, and the State of Israel

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2004:0286:FIN:EN:PDF>

##### *Korea*

2006 – Cooperation agreement on a Civil Global Navigation Satellite System (GNSS) between the European Community and its Member States, of the one part, and the Republic of Korea, of the other part

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:288:0031:0042:EN:PDF>

2006 – Council Decision of 1 September 2006 on the signing, on behalf of the Community, of the Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) between

the European Community and its Member States, of the one part, and the Republic of Korea, of the other part

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:288:0030:0030:EN:PDF>

2006 – Proposal for a Council Decision on the signing of the Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) between the European Community and its Member States and the Republic of Korea

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0141:FIN:EN:PDF>

#### *Morocco*

2006 – Proposal for a Council Decision on the signing of a Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) between the European Community and its Member States and the Kingdom of Morocco

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0220:FIN:EN:PDF>

#### *Norway*

2010 – Cooperation Agreement on Satellite Navigation between the European Union and its Member States and the Kingdom of Norway

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:283:0012:0020:EN:PDF>

2010 – Council Decision of 11 March 2010 on the signing and provisional application of the Cooperation Agreement on Satellite Navigation between the European Union and its Member States and the Kingdom of Norway

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:283:0011:0011:EN:PDF>

2010 – Proposal for a Council Decision on the signing of the Cooperation Agreement on a Satellite Navigation between the European Community and its Member States and the Kingdom of Norway

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0453:FIN:EN:PDF>

#### *Ukraine*

2005 – Proposal for a Council Decision on the signing of the Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) between the European Community and its Member States and Ukraine

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0350:FIN:EN:PDF>

#### *US*

2004 – Signature of EU/US Agreement: Agreement on the promotion, provision and use of Galileo and GPS satellite-based navigation systems and related applications

[http://ec.europa.eu/enterprise/policies/satnav/galileo/files/2004\\_06\\_21\\_eu\\_us\\_agreement\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/galileo/files/2004_06_21_eu_us_agreement_en.pdf)

## Other publications

### *Galileo*

- Brochure on Europe's Satellite Navigation Programmes - Galileo and EGNOS  
[http://ec.europa.eu/enterprise/policies/satnav/galileo/files/galileo-and-egnos-yellow-brochure-2008\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/galileo/files/galileo-and-egnos-yellow-brochure-2008_en.pdf)
- Galileo Open Service Signal In Space Interface Control Document (OS SIS ICD)  
[http://ec.europa.eu/enterprise/policies/satnav/galileo/files/brochures-leaflets/galileo-os-sis-icd\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/galileo/files/brochures-leaflets/galileo-os-sis-icd_en.pdf)
- Galileo, EGNOS and GMES  
[http://ec.europa.eu/enterprise/policies/satnav/galileo/files/brochures-leaflets/galileo-egnos-gmes-brochure\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/galileo/files/brochures-leaflets/galileo-egnos-gmes-brochure_en.pdf)
- GNSS applications  
[http://ec.europa.eu/enterprise/policies/satnav/galileo/files/brochures-leaflets/applications-leaflet\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/galileo/files/brochures-leaflets/applications-leaflet_en.pdf)
- Key results of the sixth research framework programme for satellite navigation  
[http://ec.europa.eu/enterprise/policies/satnav/galileo/files/brochures-leaflets/fp6-results\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/galileo/files/brochures-leaflets/fp6-results_en.pdf)
- Press release on the Public Regulated Service (PRS) of Galileo  
[http://ec.europa.eu/enterprise/policies/satnav/galileo/files/ip-10-1301-prs\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/galileo/files/ip-10-1301-prs_en.pdf)
- Press release "New funding for the trans-European energy and transport networks, Galileo and Marco Polo from 2007 to 2013"

### *EGNOS*

- EGNOS Service Definition Document – Safety of Life  
[http://ec.europa.eu/enterprise/policies/satnav/egnos/files/brochures-leaflets/egnos-brochure\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/brochures-leaflets/egnos-brochure_en.pdf)
- EGNOS Service Definition Document - Open Service  
[http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos-service-definition-document-open-service-v1.1-30-10-2009\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos-service-definition-document-open-service-v1.1-30-10-2009_en.pdf)
- EGNOS User Guide for Application Developers  
[http://ec.europa.eu/enterprise/policies/satnav/egnos/files/cnes-user-guide-egnos-2009\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/cnes-user-guide-egnos-2009_en.pdf)
- Leaflet EGNOS for Agriculture  
[http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos\\_agriculture.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos_agriculture.pdf)
- Leaflet EGNOS for Aviation  
[http://ec.europa.eu/enterprise/policies/satnav/egnos/files/2009\\_egnos\\_aviation\\_leaflet.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/2009_egnos_aviation_leaflet.pdf)
- Leaflet EGNOS for Road User Charging  
[http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos-road-leaflet-gsa\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos-road-leaflet-gsa_en.pdf)
- Leaflet EGNOS for Mapping  
[http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos-for-mapping-flyer\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/egnos-for-mapping-flyer_en.pdf)
- General EGNOS leaflet  
[http://ec.europa.eu/enterprise/policies/satnav/index\\_en.htm](http://ec.europa.eu/enterprise/policies/satnav/index_en.htm)

- General EGNOS brochure  
[http://ec.europa.eu/enterprise/policies/satnav/egnos/files/brochures-leaflets/egnos-brochure\\_en.pdf](http://ec.europa.eu/enterprise/policies/satnav/egnos/files/brochures-leaflets/egnos-brochure_en.pdf)

**ANNEX VI: GNSS MARKET MONITORING AND FORECASTING TOOL: METHODOLOGY**

The GNSS Market Monitoring and Forecasting Process (hereafter MMFP) provides understanding of today's GNSS market and forecasts of future developments. Its objectives are in particular to:

- provide a solid source of market intelligence on GNSS in Europe, notably to establish the real size of the main downstream market segments: location based services (LBS), aviation, agriculture and road transport (extension to maritime and mapping planned in future);
- measure the impact of the GNSS programmes and action plans in terms of economic and public benefits;
- provide a tool to support policy decisions by responding to requests of market estimation and scenario analysis;
- have a viable forecast based on present knowledge and be able to compare alternative scenarios that represent different visions on how the market will evolve.

This model has been developed with highly qualified economic and business consulting partners and involved experts from all user segments. Data is based on recognised reliable primary public sources and grouped by application and by region which enables more detailed analysis. Assumptions are based on experts' consensus. In the data gathering process more than 80 public databases and reports were consulted and more than 20 experts interviewed. The tool is flexible and the European GNSS agency is able to update it with latest data and run different scenarios.

The tool contains two models:

1. **Market Model** that aims at mapping out the GNSS market, identifying geographical opportunities and key segments for the European industry. It is using a selection of econometric methodologies, based on availability of data and on the suitability to the drivers and market trends and evolution.
2. **Public Utility Model** aims at providing an estimate of the overall economic value of the GNSS market, in particular the impact of EGNOS and Galileo on economic and social benefits for the European Union including externalities.

The structure of the MMFP is presented on **Figure 10**.

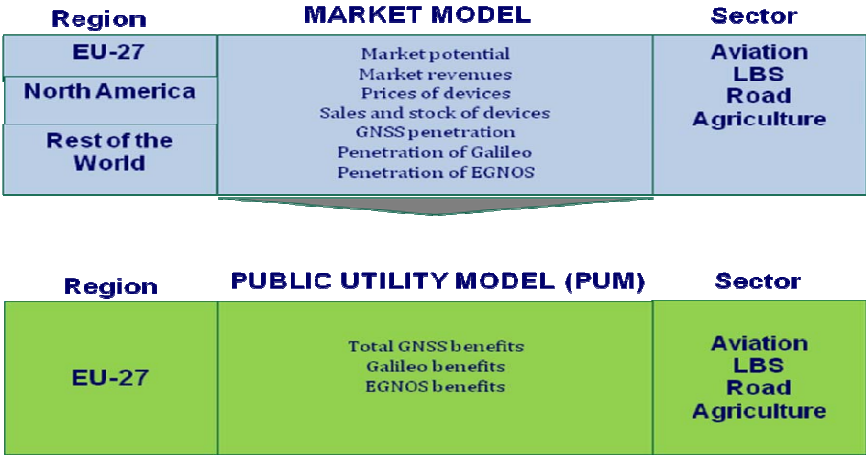


Figure 10: Structure of the MMFP



These two models in combination with additional analysis were used for calculating the indirect benefits summarised in chapter 6.1.1.2:

The total indirect benefits are equal to the sum of benefits generated in three sources:

- downstream market growth,
  - upstream market and spill over,
  - public utility (also referred to as social and environmental benefits or public benefits).
- } referred to as economic benefits

The calculation methodology of the benefits will be explained in the following sections.

### *Indirect economic benefits*

**Downstream market growth** for the EU-27 region is calculated by using the Market Model of the MMFP. Applying the bottom-up approach, market revenues are calculated for each GNSS application and aggregated to the sector level and finally to the GNSS market level. In the Market Model applications from the following 4 sectors are taken into account: LBS, road, aviation and agriculture.

The GNSS revenues are the product of shipments of devices and their price. Although the model is device-driven, additional services (e.g. sales of maps for TomTom) have been included in the calculation.

The downstream market growth represents the additional growth of the GNSS applications market that is due directly to the introduction of Galileo. It is based on assumption that the introduction of new technologies has a positive impact on the development of user applications based on these technologies, leading to faster replacement and increase in sales of devices (e.g. introduction of 3G boosted the mobile phones market).

It means that a certain share of calculated total GNSS revenues will be attributed to Galileo. This share is called Galileo delta in MMFP. The deltas are defined based on value added of EGNOS/Galileo in the following dimensions (characteristics of GNSS network): accuracy, availability, indoor penetration, authentication, integrity and EU independence.

The model is based on validated input data and assumptions, both global (equal for all sectors) and sector-specific (see Figure 11 and Figure 12 for details).

MM segment	Assumption	Value	Source
Smartphones	Share of full device price attributable to LBS	1%	Helios validation
Smartphones	Share of LBS data revenue in total smartphone data revenue	2.5%	Helios validation
Smartphones	Monthly data ARPU for Europe in 2011	€10	Helios validation
Smartphones	Peak monthly data ARPU for Europe (in 2020)	€20	Helios validation
Smartphones	Monthly data ARPU for N. America in 2011	€5	Helios validation
Smartphones	Peak monthly data ARPU for N. America (in 2020)	€15	Helios validation
Smartphones	Monthly data ARPU for ROW in 2011	€1	Helios validation
Smartphones	Peak monthly data ARPU for ROW (in 2020)	€5	Helios validation
People tracking devices	Addressable market percentage	30%	LE analysis
People tracking devices	GNSS peak stock penetration	50%	LE analysis
People tracking devices	Year GNSS peak stock penetration is reached	2035	LE analysis
People tracking devices	Galileo peak stock penetration	40%	LE analysis
People tracking devices	Year Galileo peak stock penetration is reached	2040	LE analysis
People tracking devices	EGNOS peak stock penetration	40%	LE analysis
People tracking devices	Lifetime of a people tracking device	5 years	LE analysis

Figure 11: List of sector-specific assumptions used in MMFP (example of LBS sector).

Global Assumptions (MMFP)			
Assumption name	Units	Value	Source
Average EU VAT (%)	%	19.50%	Eurostat
Average EU Corporation tax rate (%)	%	23.20%	Eurostat
Average '05-'07 earning/revenue ratio (%): Manufacturer of communication equipment - services	%	12.7%	Amadeus database
Average '05-'07 earning/revenue ratio (%): Telecommunications companies– devices	%	14.1%	Amadeus database
Average EU 27 inflation rate	%	1.6%	Eurostat
\$ to € Exchange rate conversion factor	###	0.82	OANDA
Price elasticity to offer reduction (price elasticity to a decrease in oil production)	###	5.00	VVA estimate on EIA data
Statistical value of a life (mean)	€m	2.0	European Commission (2009) PART III: ANNEXES TO IMPACT ASSESSMENT GUIDELINES, <a href="http://ec.europa.eu/governance/impact/commission_guidelines/docs/iag_2009_annex_en.pdf">http://ec.europa.eu/governance/impact/commission_guidelines/docs/iag_2009_annex_en.pdf</a> .
Value of CO <sub>2</sub> (per tonne)	€/tCO <sub>2</sub>	22.50	ICE ECX EUA Futures (Dec 2020), European Climate Exchange <a href="http://www.ecx.eu">www.ecx.eu</a> , supported by Committee on Climate Change (2009, p. 68) <i>Meeting Carbon Budgets – the need for a step change</i> , <a href="http://www.official-documents.gov.uk/document/other/978999100076/99100076/9789999100076.pdf">http://www.official-documents.gov.uk/document/other/978999100076/99100076/9789999100076.pdf</a> .
Average hourly salary (All NACE activities (except agriculture; fishing; activities of households and extra-territorial organizations))	€/hour	17.71 (2006, to be indexed)	Eurostat – Hourly labour costs - Nace Rev. 1.1 ( <i>lc_an_costh</i> ): <a href="http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database#">http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database#</a>
Value of leisure time <i>Proposed amendment from VVA estimate of 50% of salary.</i>	€/hour	33% of salary	World Bank (2005) Valuation of Time Savings (TRN-15).
Real Economic Growth (Percentage change in Trend GDP, constant prices): - Europe - North America - Rest of World	%	1.17% 1.72% 6.31%	EC DG-ECFIN AMECO <a href="http://ec.europa.eu/economy_finance/ameco/user">http://ec.europa.eu/economy_finance/ameco/user</a> ; IMF World Economic Outlook Database, <a href="http://www.imf.org/external/pubs/ft/weo/2010/02/weodata/index.aspx">http://www.imf.org/external/pubs/ft/weo/2010/02/weodata/index.aspx</a> .

Figure 12: List of global assumptions used in MMFP

**Upstream market growth & spill over** for the EU-27 region is based on:

- Gross Value Add (GVA) of the investments into space infrastructure within the Galileo programme: the GVA is estimated to be 60% of the total costs (i.e. deployment and operational costs), excluding costs of imports and raw materials. These investments result into an increase in disposable income that flows back into the economy and contributes to EU GDP;

- Spill-over effects of R&D investments are calculated with the assumption that new technologies developed for space projects are often used in terrestrial applications increasing the size of the non-space economy. The average R&D spending in UK space sector is 8% of turnover according to Oxford Economics. According to the same source, 1 EUR spent on R&D in space leads to a sustainable increase in GDP of 0.70 EUR. The model applies the same or lower ratios to the Galileo project (5% and 0.7), assuming that most of the EUR 0.8bn R&D spending occurs relatively early in the programme.

Calculation of upstream market growth and spill over is a separate analysis, not included in MMFP.

### *Indirect social and environmental benefits*

The **public benefits** for EU-27 region were calculated based on the Public Utility Model of MMFP. The GNSS benefits are externalities that are directly or indirectly generated by GNSS applications, like:

- benefits for public institutions (VAT, corporate tax)
- benefits for users (time savings, fertilizer reduction)
- benefits for society (CO2 reduction, noise reduction)

Those benefits have been firstly calculated for the network of all available GNSSs and secondly a certain share of total GNSS benefits was attributed to EGNOS/Galileo. The percentage share of benefits (EGNOS/Galileo delta) was defined based on value added of EGNOS/Galileo in the following dimensions: accuracy, availability, indoor penetration, authentication, integrity and EU independence.

The calculation of public benefits is robust and focuses on externalities with clear link to GNSS use. **Figure 13** presents examples of public benefits defined for road transport. An example of calculation of time savings in road (benefit of highest value in MMFP) is presented on **Figure 14**.

	GNSS applications defined for road transport				
Public benefits	Navigation	RUC	PPUI	ADAS	eCall
<b>Benefits for users</b>					
Travel time reduction	✓				
Fuel consumption reduction	✓				
<b>Social benefits/externalities</b>					
Air pollution reduction	✓				
Climate change (less Co2)	✓				
Severity decrease in injuries/accidents				✓	✓
Congestion reduction from avoided accidents				✓	
Saved lives				✓	✓

New jobs	✓	✓	✓	✓	✓
<b>Benefits for public institutions</b>					
Δ VAT	✓	✓	✓	✓	✓
Δ Corporation tax	✓	✓	✓	✓	✓

Figure 13: Mapping of public benefits with GNSS applications in road transport

**Example of GNSS public benefit calculation – time savings in road:**

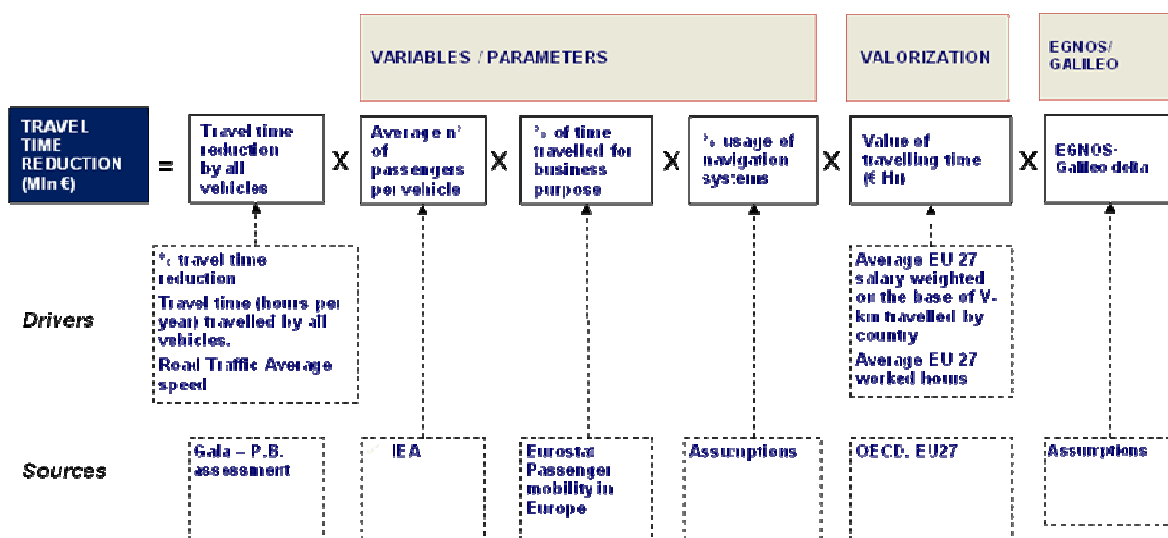


Figure 14: Example of calculation of public benefits: time savings in road transport.

The categories of public benefits have been defined with sectoral experts and the calculation was based on validated assumptions (see Figure 6 for more details).

PUM benefit	Assumption	Value	Source
Fuel consumption & Air pollution & CO2 emissions	% of km driven in urban areas	10%	VVA
Fuel consumption & Air pollution & CO2 emissions	% of urban kilometres travelled by private cars	75%	VVA
Fuel consumption & Air pollution & CO2 emissions	% modal shift from cars to public transport	2%	VVA
Air pollution	Air pollution (€/1000 Vehicle-Km)	13	VVA
Time savings for pedestrians	Time spent walking per person per day (hours)	0.30	LE analysis
Time savings for pedestrians	% of walking in urban areas	50%	LE analysis
Time savings for pedestrians	% of walking where smartphone is used for navigation	0.5%	LE analysis
Value of lives saved	Fatalities reduced to severe injuries (%)	0.1%	LE analysis
Value of lives saved	Avoided deaths (%)	0.1%	LE analysis
All	Share of smartphones which are 2 <sup>nd</sup> devices	5% by 2021	LE analysis

Figure 15: List of assumptions used in Public Utility Model (example of LBS sector).

Benefits such as lives saved and water savings are non-monetised public benefits and were estimated only for policy option 1 – baseline option. The results of non-monetised analysis were not used as an argument in assessing the impact of different policy options.

Non-monetized benefits:

- 6,000 jobs (Net jobs creation from 2015-2027)
- 8,500 saved lives (Cumulative until 2027)
- 2,000,000 lives improved (Average from 2015-2027)
- 1,2 trillion m<sup>3</sup> of water saved (Cumulative until 2027)

### ***Public benefits in different launch scenarios***

The comparison between five different policy options for problem 1 presented in Table 4 was done by preparing five different scenarios in the MMFP. The simulation of benefits was based on the following steps:

- Calculation of the Galileo delta (percentage used to define the Galileo share of market revenues and public benefits, see sections above for more details)
- Variation of this delta taking into account Galileo deployment scenarios and other GNSSs

The Galileo delta estimation (usually 5-10% of market and public utility depending on the segment) is based on the following assumptions:

- GPS characteristics are based on GPS today (2009)
- Galileo is the 2<sup>nd</sup> GNSS in use after GPS
- Galileo is deployed according to current baseline in terms of features

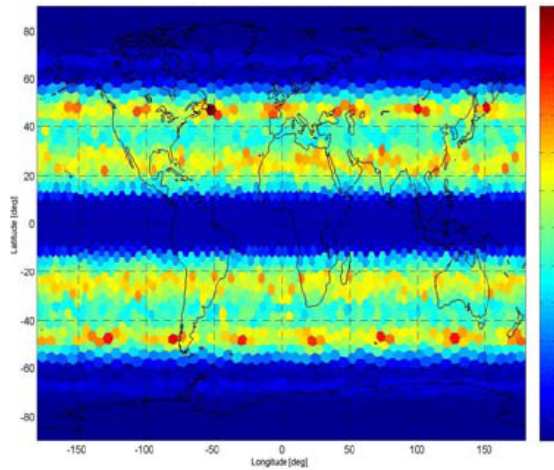
The Galileo delta is then corrected and simulated over time taking into account GPS modernisation, additional GNSS being launched (Compass and Glonass), delays in the deployment of Galileo and changes in the Galileo baseline (e.g., number of satellites, services available).

GNSSs are compared on the following 6 features: Accuracy, Availability, Integrity, Signal tracking and indoor penetration, Authentication and EU independence. For each user segment, the features are weighted according to their importance. For a given year, Galileo is compared on each feature to the best available GNSS. This comparison takes into account the number of deployed satellites and the Galileo services available. In case Galileo is clearly superior to GPS and other GNSS it takes the full value of the improvement over GPS (as modelled by the static Galileo delta). In case Galileo is providing roughly the same benefits as another GNSS or as the modernized GPS on a specific feature, this value is shared between the GNSS (e.g., divided by 3 in case Galileo, GPSIII and Compass provide the same improvements). In case Galileo does not improve significantly over current GPS, the delta is equal to 0.

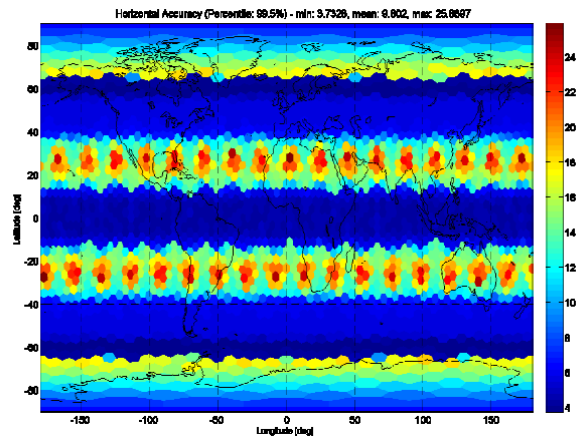
## ANNEX VII – PERFORMANCE MAPS

To give an example, below are the performance maps for Galileo horizontal accuracy for four options. Figure 4 represents option (4) where the identified worst user locations correspond to European latitudes (lighter/red spots), Figure 5 represents option (3), where most of the European latitudes are covered with a signal of good accuracy. In Figure 6 representing both options (1) and (2) the whole surface of the planet is covered by an excellent accuracy (all in blue).

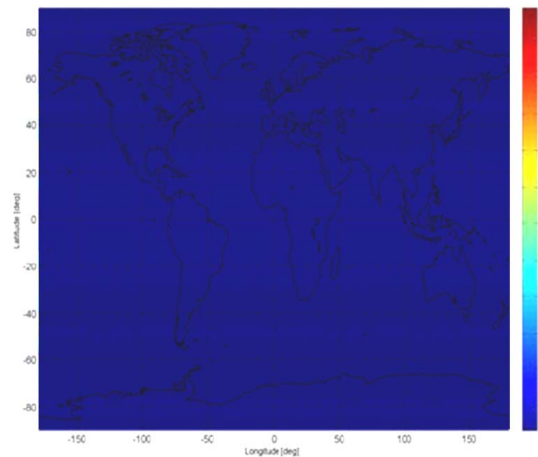
**Figure 16: Performance map for option (4)  
Galileo horizontal accuracy [m]**



**Figure 17: Performance map for option (3)  
Galileo horizontal accuracy [m]**



**Figure 18: Performance map for options (1)  
and (2) Galileo horizontal accuracy [m]**



## ANNEX VIII – GALILEO SoL SERVICE RE-PROFILING

The original Galileo SoL service has been conceived with the objective to offer a stand alone service to world-wide users and based on a proprietary solution developed for Galileo. This approach has triggered significant concerns with the SoL user communities that have clearly indicated their intent to adopt future solutions based on the combined use of satellite constellations in order to increase overall service performance and robustness. This message has been constant over the last few years and the trends observed in the on-going standardisation processes in different application domains confirm that this approach is the one pursued for the future GNSS equipments.

It is therefore proposed to adopt a revised strategy more in line with the user expectations and that favour integration with other existing GNSS systems. This decision calls for the adoption of common standards with other international GNSS service providers and also dictates to use, to the maximum extent possible, signals over common frequency bands.

A replacement SoL concept for Galileo is therefore not yet defined and should be the result of a collaborative process at international level. One of the most promising approaches identified so far would be a revised SoL concept based on an apportionment of the error detection capability between the GNSS provider and the user receiver. This would enable to reduce significantly the implementation burden for the Galileo programme while still offering interesting operational benefits for the user communities when using more than one constellation. Under this scenario, a reduced level of performance may also be available when using Galileo independently but it is unlikely to be sufficient to serve the most demanding user communities. The Commission has launched a dedicated work-plan to support a decision on the Galileo SoL re-profiling in 2013.

A SoL working group has been set-up by the Commission with experts nominated by Member States in order to help defining the new mission targets for the re-profiled Galileo SoL service. This working group is expected to provide its conclusions and recommendations towards the beginning of 2013. The programme objectives with regard to Galileo SoL would then be documented in a revised version of the High Level Document (HLD) and Mission Requirement Document (MRD).

Regarding the ground infrastructure, the main differences between B.2 and B.3 versions, the latest one supporting a standalone service could be summarised as follows:

- more ground stations to be deployed over the whole globe;
- more redundancy in the communication network;
- tighter specifications on the different elements of the ground segment in order to meet a very stringent time to alert requirement;
- potentially higher levels of software quality;
- more administrative burden to perform the qualification of the system.

