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Note

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PREFACE

By Order Form IP/A/ITRE/IC/2007-113 - EP references: IP/A/ITRE/2007-ED 528/15404 (2007) the undersigned was invited to deliver a briefing note on Galileo for the European Parliament's Committee on Industry, Research and Energy (ITRE) which should cover the following aspects:

- Assessment of the available material on risk (based on existing material, including the one from the EC)
- Assessment of the costing and financial data provided in various existing cost-benefit analyses
- What does the latest proposed management structure by the EC imply now in terms of ownership and financial matters?
- What are the possibilities and implications of a possible Public-Private Partnership (PPP) basis (or another type of cooperation) in the next phases of the project, in particular regarding the operational phase?

The briefing is based on existing available material and discussions with various experts and stakeholders, which was carefully examined and contains also the authors own expertise and assessment to the facts and figures.

EXECUTIVE SUMMARY

With the Council conclusions of Nov/Dec 2007 public governance, management structure, procurement strategy as well as overall costs and public funding were proposed by the EC and agreed between the member states.

Although the proposed public governance assigns clear responsibilities to the actors the role of the European Parliament still needs to be clarified. The proposal of the EP´s Committee on Industry Research and Energy to establish an Inter-institutional Group consisting of representatives of the Parliament, the Council´s Presidency and the Commission (ITRE) is supported as well as the inclusion of representatives of the EP as observers in the "Committee on the European GNSS Programme".

Both arrangements contribute to transparency in the GNSS programme. It is suggested to relax the reporting intervals to the Inter-institutional Group to half-year intervals.

Two options with respect to the future of the GNSS Supervisory Authority are discussed which has lost its main mandate due to the absence of a private concessionaire. The change of its structure into a GNSS Security Agency is favoured in order to guarantee proper treatment of all security aspects of the GNSS programme.

The other remaining functions could be incorporated into the structure of the programme manager (EC). No financial savings are possible in the proposed budget by closing the GSA since costs including personnel are covered by the general administrational budget of the EC.

The planned procurement strategy should enable competition as well as enable dual or multiple sourcing for items whenever possible since these are the main instruments for keeping costs down. Minor clarifications are still needed with respect to the procurement of the satellites in three batches and the consideration of SME´s.

In the next months it is necessary to establish still the detailed working rules and to build up the necessary structures (recruitment of staff in EC´s programme managing unit and ESA´s directorate on navigation).

A central role is played by the EC-ESA agreement. Member states are urged to clearly define use and corresponding implementation and handling of the Galileo Public-Regulated Service with its security requirements.

Most important is that a lean and effective management on all sides be built up where the different (political) actors do not over-constrain nor steadily and continuously intervene once the working rules are established in detail (hopefully by autumn/end of 2008).

The estimated overall cost for the Galileo Full Operational Capability of 3.4 B€ seem to be a reasonable ceiling price based on present best knowledge estimated by various institutions/companies/industry. It contains contingencies in the order of 12 to 13%.

Various risks are still contained in the programme (as it is the case in every space programme) ranging from management and procurement risks, design and development risks, deployment risks, market and operational risks as well as the ones which may come from outside.

As a consequence delays of up to two years and costs overrun of up to 25% of the present budget may still happen which could not be absorbed by the 12 to 13% Contingency budget.

The business model for the operational phase has still to be studied in the next years enabling private industry to assess more accurately the possibilities of commercial revenues and gaining more experiences with the system itself.

Considering the corresponding 1995 findings of the US (with regard to possible direct revenues for the US Global Positioning System) and the occurrence of other global navigation satellite systems over the next years, it is still questionable whether direct revenues can be recovered from Galileo.

Nevertheless, in short, the new developments for the European GNSS programme seem to lead to a more sound and realistic way for building it up. The public funding is fully justified by the strategic and high-tech nature of satellite navigation which will play an important role in the life of every citizen in future.

ACRONYMS

CS	Commercial Service
EGNOS	European Geostationary Navigation Overlay System
FOC	Full Operational Capability
GAGAN	GPS Aided Geo Augmented Navigation (India)
GCC	Ground Control Centre
GNSS	Global Navigation Satellite System
GPS	Global Positioning System (USA)
GRAS	GPS Regional Augmentation System (Australia)
GSA	European GNSS Supervisory Authority
IOV	In-Orbit Validation
IRNSS	Indian Regional Navigation Satellite System
MSAS	Multi-functional Satellite Augmentation System (Japan)
OS	Open Service
PPP	Public Private Partnership
PRS	Public Regulated Service
QZSS	Quasi-Zenith Satellite System (Japan)
SoL	Safety-of-Life Service
WAAS	Wide Area Augmentation System (USA)

1. INTRODUCTION

1.1 Galileo – A brief outline

Galileo is the European global satellite navigation system developed by the European Union and the European Space Agency (ESA). It will consist of 30 satellites in an orbit with an altitude of approx. 23 000 km above the surface of the earth, and a worldwide net of approx. 40 ground stations. Ground control centres will be established in Oberpfaffenhofen (Germany) and Fucino (Italy) together with a Safety-of-Life centre in Madrid (Spain).

Two main reasons led to this decision: Europe's independence from other global navigation systems and autonomy, and secondly, to get a share in this tremendously growing worldwide high-tech market, which is practically today dominated by the US Global Positioning System (GPS).

Unlike GPS and also the Russian Glonass system, Galileo is designed "as a civil system under civil control". However, this does not preclude the possibility that it might be used for military purposes in the future.

Galileo basically will offer five services:

- The **Open Service (OS)** is available free-of-charge for mass market applications not requiring any guarantee.
- The **Safety-of-Life Service (SoL)** is a guaranteed enhanced service for safety-of-life transport applications, e. g. in civil aviation and the maritime sector, equipped with integrity warnings within a certain alarm time when the system is malfunctioning outside the specifications. The service will be certified against available standards.
- The **Commercial Service (CS)** provides improved accuracy and higher data throughput rate for professional use and is encrypted.
- The **Public Regulated Service (PRS)** is reserved for governmental, public and strategic applications which require a high continuity in times of a crisis and more robustness to interference. Access to this encrypted service is for authorized users only.
- The **Search and Rescue Service** relays distress alarms as Europe's contribution to the existing international COSPAS-SARSAT cooperative humanitarian activities.

As a second generation satellite navigation system[1], Galileo will offer several signal enhancements resulting in improved accuracy, more resistance against multi-path reflections and interference and provides with global integrity a main differentiator to GPS.

Negotiations over several years have led in 2004 to the **EU-US Agreement on the Promotion, Provision and Use of GALILEO and GPS Satellite-based Navigation Systems and Related Applications** providing for the user interoperability between both systems by adopting a common signal, timing and geodetic standards to facilitate the joint use of Galileo and GPS in a single receiver. In addition, the agreement preserves national security compatibility and non-discrimination in trade of satellite navigation goods and services and not to restrict access to respective open services by end-users.

[1] The presently available global satellite navigation systems like the US GPS and the Russian Glonass were designed and developed in the 1970/1980s and represent the first generation in satellite navigation technology.

The Galileo project is carried out in four phases:

(1) The **Definition Phase** was completed in 2001 at a cost of 133 M€ shared equally between the European Union (EU) and the European Space Agency (ESA). It resulted in the system design and architecture as well as in the definition of the services (mentioned before).

(2) The **Development and Validation Phase** started in 2002 and should originally run until 2005. Two experimental satellites (GIOVE-A, GIOVE-B) were to be launched; the first is successfully in orbit since 28 Dec 2005 and fulfilled its primary task to secure the frequency filings. Launch of GIOVE-B is scheduled for the second quarter of 2008. In-Orbit Validation (IOV) using four fully-fledged satellites in a mini-constellation is commencing in 2009 and will last until 2012 according to present ESA planning.

(3) The **Deployment Phase** is building up the full Galileo system by launching the remaining 26 satellites and building up the ground structure (2011 to 1013). It was intended to have a Public Private Partnership (PPP) where industry ("the concessionaire") would contribute 1,4 B€ against 700 M€ from the EU budget.

PPP negotiations collapsed in spring 2007 and have led to a re-profiling[2] of the Galileo system and a new procurement and governance strategy[3]. The European GNSS Programme[4] is now funded publicly[5] with 2,4 B€ summing up the whole programme to 3,4 B€.

The Commission will be now the Programme Manager whereby through an agreement, ESA will act as the procurement agent.

The new procurement structure divides the Galileo system into six working packages (system engineering support, ground mission infrastructure completion, ground control infrastructure completion, satellites, launchers, operations).

(4) The **Operational Phase** originally planned to be carried out by the concessionaire in PPP will start after the full operational capability (FOC) most likely in 2013.

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[2] Progressing Galileo: Re-Profiling the European GNSS Programmes. Communication from the Commission to the European Parliament and the Council, Staff Working Document, 19 Sep 2007

[3] Council Conclusions on Launching the European Global Navigation Satellite System Programmes. 2835th Transport, Telecommunications and Energy Council meeting, Brussels, 29-30 Nov and 3 Dec 2007

[4] The European GNSS Programme includes the EGNOS (European Geostationary Navigation Overlay System) system as forerunner to Galileo. EGNOS is a so-called augmentation system (additional geostationary satellites and a European ground network) that is based on GPS signals and that transmits integrity messages and additional correction signals in order to allow terrestrial receivers to determine their position with much higher accuracy than possible with GPS only. EGNOS is foreseen in particular for aviation and will be the initial backbone of the European Air Traffic Management system (SESAR) before Galileo becomes operational. EGNOS will be operational 2008-2009.

[5] 2833rd Council of Economic and Financial Affairs, Brussels, 23 Nov 2007

1.2 Galileo – steps so far

In the following the steps in the Galileo programme are briefly outlined:

1994	Transport Council Resolution to support **augmentations (GNSS-1)** to the US Global Positioning System (GPS) and to **initiate preliminary work for a satellite navigation of the next generation (GNSS-2)**
21 Jan 1998	EC Communication on a **strategy** for global satellite navigation
February 1999	EC sets out **rationale for a European Global Satellite Navigation System**
Dec 2000	Nice European Council of Heads of State and Government agrees to **fund the Galileo development phase through Public Private Partnership (PPP)**
April 2001	Transport Council resolution to **launch the Galileo programme**
26 March 2002	**Launch of Galileo Development Phase**
24 March 2003	Agreement between EU member states on the **division of budget contributions**
10 June 2003	**Galileo Joint Undertaking** (GJU – founded as a private company) **in operation.** Main task was the selection of the Concessionaire (private industry consortium) for carrying out the development and deployment phase by PPP GJU closed end of 2006
12 July 2004	**EC Council Regulation on the Establishment of Structures for the Management of the European Satellite Radio-Navigation Programmes** (Creation of the European GNSS Supervisory Authority)
26 June 2004	**EU-US Agreement on the Promotion, Provision and Use of GALILEO and GPS Satellite-based Navigation Systems and Related Applications** (Interoperability between Galileo and GPS)
June 2005	European industry consortium called the **Concessionaire** selected
28 Dec 2005	**Launch of first Galileo satellite (GIOVE-A)** Main task is to secure the frequency filings
6-8 June 2007	European Council takes notice that **negotiations with the concessionaire collapsed**
23 Nov 2007	European Council and Parliament reach **agreement on Galileo public financing**
29-30 Nov, 3 Dec 2007	EC Council Conclusions on launching the European Global Navigation Satellite Programmes (**management, procurement and governance**)

2. PUBLIC GOVERNANCE, MANAGEMENT STRUCTURE AND PROCUREMENT STRATEGY

2.1 Public governance and management structure

The public governance and management of the Galileo programme was proposed by the EC[2] and endorsed by the EU Council in its 29-30 Nov / 3 Dec 2007 meeting[3]. It is still subject of adoption of the corresponding regulation by the Council and the European Parliament (the decision process is still underway).

The proposal of the EC is as follows (see also Fig. 1):

- **Political oversight** should be assured by the Council and the European Parliament.
- The European Commission acts as **"programme manager"**.
- The EC is assisted by a **"Committee on the European GNSS Programme"** with representatives of the member states and maybe, representatives of the Administrational Board of GSA and the Program Board on Satellite Navigation of ESA.
- The GNSS Supervisory Authority (GSA)[6] is **assisting** the EC, acts as **Accreditation Authority** and is responsible for preparing the market and organizing certification.
- The European Space Agency (ESA) is the **"prime contractor" or "procurement agent"** and **"design authority".**
- Galileo is owned by the European Union.

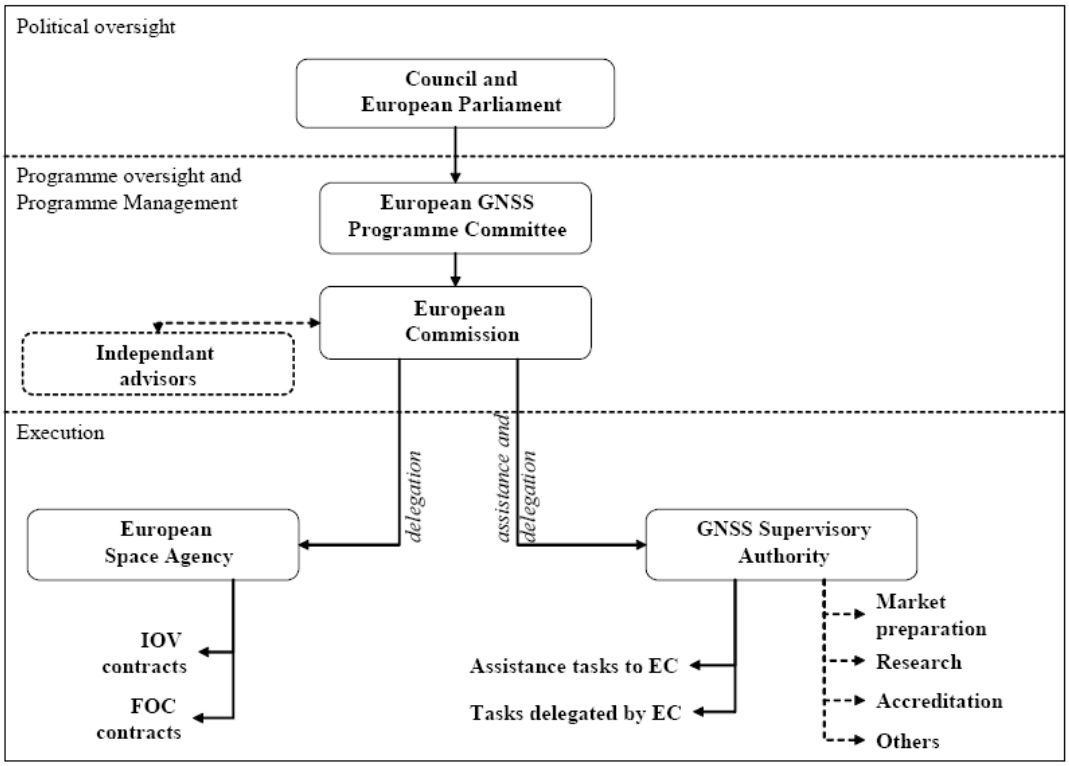

Figure 1. Public Sector Governance of the GNSS Programme[2]

[6] The GSA was established as a Community Agency on 12 July 2004, by Council Regulation 1321/2004, status amended in 2006 by Council Regulation No 1942/2006.

2.2 Comments on the public governance and management structure

In order to carry out the political oversight of the programme the European Parliament's Committee on Industry, Research and Energy (ITRE) has quite recently proposed to set up an Inter-institutional Monitoring Group (IMG) consisting of representatives of the Parliament, the Council's Presidency and the Commission. At quarterly intervals the Commission would report to this group on the ESA's decision-making process, procurement procedures, competition and the relevant EU markets as well as on the physical progress made against the programmes drawn up for the Galileo project, and the financial implications[7]. This seems to be good instrument to ensure transparency of the program. Perhaps reporting can be minimized by accepting half-year intervals in between.

MEP´s further asked for the inclusion of observers of the European Parliament in the "Committee on the European GNSS Programme" (consisting of representatives of the member states, and maybe, of the Administrational Board of GSA and the Program Board on Satellite Navigation of ESA) in order to ensure the security requirements of the programme.

In any case, there is certainly the risk (see also chapter 4) that the public side is over-constraining (EC, EP, Committee on the European GNSS Programme) the programme which might easily transfer in delays, additional cost and uncertainties for the future. It is more than important to minimize administrational requirements and to establish now a lean and effective management on all sides.

The EC as program manager and ESA as prime contractor have to establish the necessary working unit (EC) and directorate, respectively. As foreseen by the EC[2], in order to cope with the working load, each institution has to recruit new personnel in the range of (at least) 30-40 staff members. This is not an easy task in consideration of the labour market in this sector.

A key role will be certainly the EC-ESA agreement which has to be worked out. ESA (which has a different member community than the European Union) has to follow the Community's procurement rules (different from ESA´s usual geographical return principle) thereby ensuring that it can built-up, as design authority, a state-of-the-art competitive satellite navigation system. Whereas overall liability questions probably stay with EC, ESA has to be incentivized to act as efficient procurement agent with obvious no or limited ability to take and manage risks.

2.3 The European GNSS Supervisory Authority (GSA)

The GSA has lost its primary role as supervisory authority on the concession. However, as per the existing Council Regulation establishing GSA[6], there are still remaining tasks which are:

- Market preparation for and commercialisation of the Galileo operational phase
- Research of benefit to the development and promotion of the European GNSS programme (within the EU 7th Framework Programme - FP7)
- Technical certification of the components and services of the Galileo system
- Management of the security aspects of the Galileo programme (security accreditation)
- Coordination of the Member´s actions in respect of the frequencies of the system

[7] http://www.europarl.europa.eu/news/expert/infopress_page/057-19758-029-01-05-909-20080128IPR19732-29-01-2008-2008-false/default_en.htm

- Managing the agreement with the economic operator charged with operating EGNOS and of presenting a framework of the future policy options concerning EGNOS
- Assistance to the Commission in execution of the GNSS programme

Insofar EC has promised to submit a "proposals for a Revision of the mentioned Regulation[6] as soon as the EU´s political decisions on the programme are taken"[2].

The European Parliament's Committee on Industry, Research and Energy (ITRE) has also quite recently[8] considered – among others things - to abolish the GSA (because of the failure of the concession) and that its remaining functions (and eventually the agency itself) could be incorporated into the structure of the Commission and/or ESA.

There is no doubt that the name GSA is no more appropriate when looking to the remaining tasks.

Having ESA´s role in mind it might be only suitable if part of the research tasks – as long as they are space technology-related – could be taken up by ESA. Most of the research of GSA, however, is GNSS application-oriented which is not of interest to ESA and, in addition, funded through the EU 7th Framework Programme. Thus, the various tasks - except maybe the coordination of frequencies – could not be given to ESA as procurement agent and design authority.

Thus, incorporation of various tasks into the GNSS programme unit of the EC/DG TREN is a feasible option. Since the GSA staff has already built up considerable expertise, and the EC as programme manager of the Galileo programme needs assistance in fulfilling its task (and in addition, needs new personnel, as mentioned before), personnel could be transferred also to the corresponding EC department, as program manager.

The GNSS market development (as a task for GSA) should not be, in general, handled by a public or governmental agency. It may lead to economic disequilibrium on the market. If at all regulations would become necessary it could be handled by the EC as program manager.

There are two tasks which (perhaps) cannot be handled properly in the EC environment itself: these are the GNSS security aspects and the certification.

As a consequence two options are coming up:

Option 1: GSA is re-structured into a GNSS Security Agency (even the acronym GSA could be kept) managing all security aspects of the GNSS programme. Space-technology related research will only be carried out by ESA in order to avoid duplicate work. All other tasks and the corresponding personnel are transferred to the EC as programme manager.

Option 2: GSA is re-structured into a Galileo Security Agency (even the acronym GSA could be kept) managing all security aspects of the GNSS programme. Space-technology related research will only be carried out by ESA in order to avoid duplicate work. ESA could be also in charge of the technical aspects of certification. The administrational aspects could be taken over by the EC or all or parts of it contracted out to an institution similar like the "Technischer Überwachungsverein (TÜV)"[9] in Germany or other countries. All other remaining tasks and the corresponding personnel are transferred to the EC as programme manager.

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8 http://www.europarl.europa.eu/news/expert/infopress_page/057-19758-029-01-05-909-20080128IPR19732-29-01-2008-2008-false/default_en.htm

9 See, for example, http://www.tuev-sued.de or http://www.tuev-nord.de

Before taking a decision for one or the other options, financial and other necessary efforts for their implementation should be compared to those ones in which GSA is left as it is and where only internal re-structuring in GSA would take place.

Since the GSA costs including the personnel are covered by the general administrational budget of the EC, and additional personnel is anyway needed for the programme manager, no further savings in the proposed budget of the GNSS programme of 3,4 B€ is possible. To what extent synergy effects may lead to a smaller number of additional personal needed for the EC as program manager, when, in particular, the technical staff is incorporated in the EC cannot be assessed by the author.

2.4 Procurement strategy

The EC proposes the following procurement strategy[3]:

a) Split of the procurement of the infrastructure into a set of six main work packages as procurement break-down; this does not rule out the prospect of multiple simultaneous procurement break-down; this does not rule out the prospect of multiple simultaneous procurement strands for individual work packages, including of satellites; The six main working packages are:

   (i) System engineering support

   (ii) Ground mission infrastructure completion

   (iii) Ground control infrastructure completion

   (iv) 26 Satellites (batch a: 10-12, batch b: 6-8, batch c: 6-8)

   (v) Launchers

   (vi) Operations

b) All work packages for FOC Galileo should be open to the maximum possible competition, in line with EU procurement principles, and to ensure procurement in space programmes are more widely open to new entrants and SMEs, while ensuring technology excellence and cost effectiveness.

c) Competitive tendering of all packages in a single procedure whereby any one independent legal entity, or legal entities part of a group, may bid for the role of prime contractor for a maximum of two of the six main work packages.

d) At least 40% of the aggregated value of the activities to be subcontracted by competitive tendering at various levels to companies other than those belonging to the groups of which entities will be prime contractors of any of the main work packages.

e) Dual sourcing wherever appropriate in order to mitigate programme risks and avoid single-source dependencies and to ensure better overall control of programme, cost and schedule.

f) Possibility for European industries to rely on non-European sources for certain components and services in case of demonstrated substantial advantages in terms of quality and costs, taking account of the strategic nature of the European GNSS programmes and of the EU security and export control requirements.

g) Implementation of an integrated programme risk management at all levels of the programme as well as structural measures to identify, control, mitigate and monitor risks.

h) Implementation of the above elements and principles on the basis of an EC-ESA Delegation Agreement in all industrial contracts.

2.5 Comments on the procurement strategy

The proposed procurement strategy enables competition – a pre-requisite for keeping the budget in limits - although the detailed implementation has still to be done; for example by defining the EC-ESA Delegation Agreement and by clarifying a few items like the procurement of the space segment in three strands (possibilities of having different industry in each one of the three batches of satellites to be procured?) or to what extent SME´s have to be considered in the GNSS programme. The 40% rule is certainly a good step in this direction, however, does not define a portion for SME´s.

3. COSTING AND FINANCIAL DATA

3.1 Available information

Information on costing and financial matters which was available for this briefing note are the estimate of EC[1], ESA´s FOC cost estimates[10], the estimate of studies carried out for EC/GSA by Satel Conseil International[11] (as well as the early ones starting around 2001) and an estimate by space industry[12] from autumn 2007. Cost benefit considerations were also discussed by the UK[13]. Valuable discussions of the author took place with representatives of the EC Galileo unit, GSA, national space agencies and European space industry. No doubt that the cost of the Galileo programme has escalated steadily over the last years. As a clear consequence decisions about the procurement of FOC should be taken fast.

IOV costs of the order of 1.5 B€ were financed and ruled by the TransEuropean Networks. Therefore they cannot be found in the considered budget of 3,4 B€ (Table 1). Unfortunately, there was a cost overrun of the order of 350 M€ due to delays, underestimation of security costs, technical consequences of the EC-US 2004 Agreement on the interoperability of Galileo and GPS (modifications for the agreed joint Galileo-GPS signal, etc.), and dealing with one single customer (European Satellite Navigation Industries) - which is not yet covered.

A solution has still to be found how this IOV cost overrun of 350 M€ can be compensated. The EC is assuming that "… possible cost overruns of the IOV phase will be covered by the current financial arrangements and/or the Contingencies reserve"[2] of the FOC budget.

3.2 Comparison of different cost estimates

The overall programme costs of 3,4 B€ as proposed by the EC and endorsed by the Council[2,3] includes the procurement of Galileo FOC, operational costs, the costs for EGNOS, the procurement agent (ESA), programme management costs and a contingency for the period 2007-2013.

In fact, the EC followed for the cost estimates largely the ones of ESA which seem to represent a ceiling price (based to a large extent on industry proposals) when compared to all earlier cost estimates EC/GSA received in their studies and concession negotiations. Table 1 lists the EC and ESA estimates.

In discussions with major European space industry the author received estimates (Industry 1) which are also listed in Table 1. Since in some items the cost estimates of EC, ESA and industry (Industry 1) consider different assumptions, e. g. with respect to the number of satellites in reserve, the use of different launchers, or the number of Ground Control Centres (2 or 3 MCC[14]) the author has added an extra column (Industry 2) with modified industry estimates (so far it was possible) in order to derive to numbers comparable to the ones of ESA and EC. Therefore the assumptions of EC and ESA were considered in "Industry 2". Footnotes in Table 1 indicate the modifications.

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[10] ESA Galileo FOC Cost Estimates, presentation, Brussels, 30 Aug 2007

[11] Satel Conseil International, Galileo Deployment Costs, presentation, Brussels, 30 Aug 2007 and Final Report for GSA for the provision of an analysis and evaluation of the costs related to the Galileo Infrastructure, 20 July 2007

[12] Personal communication

[13] House of Commons, Transport Committee, Galileo: Recent Developments. Published on 12 Nov 2007

[14] Spain intends to build up a third GCC by its own which, however, from the technology point of view is not necessary.

Table 1: European GNSS programme cost estimation

Item	ESA (M€)	EC (M€)	Industry 1 (M€)	Industry 2 (M€)
Galileo FOC				
Space Segment	1,600.6	1,600.0	2,047[15,16]	1,819
Ground Segment	399.0	400.0	412	412
Operations, Network and Sites	275.2	275.0	456[17]	400
Systems Engineering Support	151.2	150.0	330	330
Procurement Agent	194.4	195.0	350[18]	194[20]
EGNOS				
Exploitations and operations (2008-2013)	330.0	330.0	300	300
SUPPORT to PROGRAMME MANAGEMENT				
Programme management support and advisory services	50.0	27.0	27[21]	27[21]
Contingencies	399.6	428.0	270	270
Grand Total	**3,400.0**	3,405.0	4,192	3,752

When comparing the final "Grand Total" values, the (corrected) industry estimate deviates by 11% from the EC estimate. The main differences in the single items are in the space segment / satellite costs (38 M€ instead of 32,4 M€ per satellite), in initial operations and systems engineering (now with ESA and considering lower labour costs than industry) where also 80 M€ where considered by industry for security.

Programme management support costs (EC) and cost for advisory services (independent experts, the GNSS Committee, etc.) are 27 M€.

Costs for the Procurement Agent (ESA) are 195 M€.

Contingencies in the range of 428 M€ are included which should cover unexpected events and eventually the IOV cost overrun (see also the risks in chapter 4).

Considering that in all estimates are uncertainties of the order of 10%, and the procurement strategy foresees competition (which may solve for the projected 11% higher cost estimates of industry) **the EC estimate of total costs of 3,4 B€[19] represents a reasonable best ceiling price according to present knowledge.**

[15] Industry estimate considers eight satellites in reserve,, EC/ESA only two satellites in reserve (as well as different launchers,)

[16] Industry has considered 3 launches with modified Ariane 5 and four launches with Sojuz whereas the ESA estimate is based on thirteen launches with Sojuz

[17] Includes 2.5 yrs with 2 GCC, 1 yr with 3 GCC whereas the EC/ESA estimate assumes 4 yrs with 2 GCC incl. security centre – Difficult to modify, own estimate is 400 M€

[18] Industry 1: Higher than ESA itself estimated for it as procurement agent

[20] Here ESA estimate is taken

[19] Just a number for comparison: The US spend annually a budget of 1 B$ = 0.7 B€ for GPS including all cost like maintenance, replenishment, operations and research.

It was quite recently reported in the press[20] that the final price of Galileo would be at least 5 B€ and could climb to as high as 10 B€. No reliable reference is available to explain where the number is coming from. However, one explanation could be that when adding the costs of the definition (0,133 B€) and IOV phase (1,5 B€) together with the FOC budget of 3,4 B€ one is coming into the mentioned 5 B€ range. Counting also the EGNOS costs to date (0,52 B€) and the funding for Galileo related research through Framework programmes FP5 – FP7 (0,48 B€) one can even come to the total amount of € 6,4 B€[13]. There is no doubt that possible delays, risks in the programme itself (see chapter 4) and possible absence of direct commercial revenues in the operational phase may lead to an increase of this number.

[20] http://www.spiegel.de/international/europe/0,1518,528441,00.html

4. ASSESSMENT OF RISKS

4.1 Available information

Galileo programme risks and related likelihood, possible mitigation and management is summarized in the Commission Staff Working Document of 19 Sep 2007[1]. It is based on several studies carried out in the last years by Willis, Ltd., London, UK, an insurance broker company, on results of (failed) concession negotiations (using the input from European industry in their application as concessionaire) and GSA expertise. In addition the authors' knowledge was considered in the following risk outline.

4.2 Risks in the GNSS programme – an outline

The following risks are in the GNSS programme:

(i) Management and procurement risks

According to the EC proposal, the EC will act as "programme manager" whereas ESA will be the "prime contractor" or "design authority" of the GNSS programme. Both institutions have not yet the required management structures established (Status 01 Feb 2008). It is a completely new task for EC to manage a space programme. In order that EC can carry out properly its duty as programme manager, the EC estimates that a recruitment of 35 to 40 additional staff members is necessary[2]. Since the labour market for professionals in the field of satellite navigation is presently very small, delays (and subsequent cost) may occur.

Following the EC proposal it will be supported in its work by a "Committee on European GNSS Programmes"[21] which may consist of representatives of the member states, the GSA and the programme board on satellite navigation of ESA. Here member states may block the programme and cause delays.

On the ESA side a new directorate of the Galileo Programme and navigation related activities has to be founded which might partially consist of staff of the existing Directorate of Telecommunication and Navigation and also of new personnel in the same range (35 to 40) to be recruited like it is the case at EC. In addition, EC and ESA have to establish an agreement on the managements of funds and the details of the programme.

All the processes mentioned before will take between 3 and 7 months according to present estimates of the EC; they started only quite recently (Jan/Feb 2008). Given the administrational requirements and the problem of finding appropriate personnel it can be expected that at the earliest the management structure for the GNSS programme is only established in the last quarter of 2008. Any delay will have an impact on the schedule of the Galileo programme.

The main principles of the procurement strategy are defined by the Transport Council decision of Nov/Dec 2007[2]. Details have to be agreed upon now in cooperation with the member states. Although it is believed that with this framework the procurement can meet the objectives, a certain risk is there that the involvement of the member states with its industry policy may also delay or complicate the procurement, and consequently may cause additional costs.

[21] Amended Proposal for a Regulation of the European Parliament and of the Council, COM(2007), 19 Sep 2007

(ii) Design and development risks

In order to build up a competitive and state-of-the-art satellite navigation of the second generation, new developments took place which (among others) are the new atomic clocks (H-Maser) and the implementation of global integrity[22] in the system; the last is a clear differentiator to the American GPS. The performance of the new H-Maser clock will be tested soon by the second Galileo test satellite, GIOVE-B, to be launched in the second quarter of 2008. Further risks in this category concern the Safety-of-Life Service performance and the clear definition and implementation of the Public-Regulated Service with its security requirements. The last is mainly a task the member states have to clarify as soon as possible.

(iii) Deployment risks

The main risk which has to be outlined here is the uncertainty in the launch concept which should be based on multiple Ariane-5 launches and/or Russian Soyuz dual satellite launches. The upper stage of the Ariane-5 would have to be modified to carry six Galileo satellites. Although the budget for this necessary action may be covered by another (ESA) budget, it may impact mainly the presently anticipated time schedule since the corresponding launches for a Full-Operational Capability (FOC) of Galileo have to be started in 2011 in order to have the full system ready in 2013. Independent of the choice of the launch vehicle, there is still the risk of launch failures – inherent in each space programme as well as the up-scaling from the In-Orbit Validation (IOV) phase to Full-Operational Capability (FOC).

(iv) Other

In this category may fall unexpected events impacting from outside and not under control by Galileo programme. With the launch of the first Chinese Compass satellite on 3 Feb 2007 we can expect soon a new (the fourth global one after GPS, Glonass and Galileo) satellite navigation system in orbit. It is not known at present, how fast the Chinese side can built up the system (before Galileo FOC in 2013?). India is building up its regional system (IRNSS – Indian Regional Navigation Satellite System), Japan its Quasi-Zenith System (QZSS). All systems have to be closely watched. Signal overlay issues and other unforeseen items may require modifications in Galileo in order to ensure the required performance and (regional) market competitiveness and penetration.

(v) Market and operational risk

Market considerations and risks in the operation of Galileo after 2013 will be not considered in this note. Since it is not yet clear under which business model the operations may take place (see also chapter 5) and third party systems may appear whose design and performance, and consequently its impact on Galileo is presently difficult to predict - see (iv) – any statements are speculative, in particular whether there are revenues possible or not. A commercial service is already designed in Galileo. Whether under the business model of operations (which is not yet decided) any modifications will become necessary, cannot be answered now.

The following table summarizes in a simplified way the risks mentioned above, possible additional costs required in case of that event, and possible delays as well as risk mitigation actions and remarks. Approximate numbers are based on studies carried out for EC/GSA.

[22] Integrity is the ability of the system to inform the user when the performance of the system is not within the specified limits. A so-called integrity message is transmitted by the system within a certain time limit, say, 6 seconds.

Table 2. Summary of Galileo programme risks and associated impact on cost and schedule

Risk category	Main source of risk	Impact on costs	Delays	Mitigation remarks
Management and procurement	Built-up of program structures at EC, ESA, Committee, EP, member states procurement complexity	Industrial teams have to be maintained (~200 M€)	Possible (1-2 yrs)	Minimizing (political) governance[23], reliable and foreseeable decisions, effective (risk) management
Design and development	Clock, integrity, SoL performance, reduced satellite life time, PRS definition and security	Up to 500 M€	Possible (6 months to 2 yrs)	Clock tests soon (GIOVE-B), fast decision of member states on PRS and related security
Deployment	Launch vehicle, launch failure, up-scaling from IOV to FOC	100 to 250 M€	Possible (6 months to 2 yrs)	ESA and member states have to find alternatives
Others (outside the Galileo programme)	Signal changes and modifications due to third party satellite navigation systems	50 to 100 M€	Possible	Risk mitigation through international consultations
Market and operational phase	Third party navigation systems, no revenues	Full public funding in operational phase required	Possible (6 months to 2 yrs)	Problem of market competitiveness and penetration after FOC

ESA has the so-called 120% budget rule for its space projects - meaning that in case of unexpected events in the development additional costs of up to 20% are accepted without new decisions on the programme – this is unfortunately not the case in the FOC budget and where the EC is the program manager.

Cost estimates for possible risks in the GNSS programme as outlined in Table 2 may sum up easily to 20% (or even more). Contingencies in the budget, however, are only of the order of 12 to 13% and the IOV overrun costs also have to be covered.

[23] *"… commercial firms view political risks – that is uncertainty surrounding future policy directions – as the greatest potential threat …"* Cited from Scott Pace, Gerald P. Frost, Irving Lachow, David R. Frelinger, Donna Fossum, Don Wassem, Monica M. Pinto, *The Global Positioning System Assessing National Policies*, RAND Corporation, 1995 – see also chapter 5

5. CONSIDERATIONS ON THE BUSINESS MODEL OF THE OPERATIONAL PHASE

5.1 Approach for finding the proper solution

One of the reasons that the "Public-Private Partnership" (PPP) negotiations with the possible "concessionaire" (a consortium of 8 European companies) failed in spring 2007 is that industry did not want to overtake the risks (as outlined in chapter 4). When analyzing these ones, it is to some extent understandable that the necessary experiences for a proper risk assessment were not yet available. In other words, it is probable worth to re-discuss these issues after enough Galileo satellites are tested in orbit. Obvious to mention that the EU member states still have the intention to recover as much as possible of the amount of money spent for the development and deployment as well as for the operational phase.

The Transport Council has therefore in its Nov/Dec 2007[2] meeting concluded, that decisions about the follow-up of the deployment phase, namely with regard to the "*commercial*" operating phase of the European GNSS programmes can be taken only after a phase of detailed technical, commercial, financial and programmatic studies.

A possible scenario may look then like follows (based on discussions with EC):

- Starting 2009 EC/GSA prepares studies on that topic
- Industrial studies on the possibilities for a proper business model in 2010-2012 carried out for EC/GSA
- Start of operations after 2013 with an operator for a short period of, say, five years
- After that time enough information should be available to make a sound decision about the business model for the operation and maintenance of the Galileo system. In particular, at that time it can be reliably decided whether a financing under a public-private partnership principle is still possible, or other forms of funding are required.

5.2 Some remarks on the commercial potential of Galileo

Possible revenues discussed for Galileo up till now are mainly based on three major sources:

(i) Fees for authentication of the Open Service (OS), receiver fees and royalties, etc. (OS itself is free of charge)

(ii) Provision of the Public Regulated Service (PRS) to the European governments

(iii) High Accuracy Service of the Commercial Service (CS)

Studies for/by EC/GSA still consider/assume a commercial potential and revenues for the Galileo applications mentioned above.

The following critical remarks are based on the author's own assessment:

Ad (i) Acceptance of fees and royalties on OS receivers in the market will rely on the fact whether Galileo is adding a significant value for customers. If through interoperability the Russian Glonass system[24] or the Chinese Compass[25] system practically replaces Galileo by adding satellites to the existing GPS system, chances are very low for asking for fees and royalties on (combined) Galileo receivers. In addition, there will be no more Galileo-only receivers in future. Due to the EU-US 2004 agreement interoperability between Galileo and GPS is ensured, and thus, there will be only combined receivers on the market. In fact, there will be only combined Galileo-GPS receivers in future markets. Since the EU-US agreement has also agreed on non-discrimination of products of both systems and free trade, it is questionable whether fees or royalties can be put on such receivers. Real chances might become available through national and/or EU regulations with regard to the use of Galileo authentication and other features.

Ad (ii) PRS policy is not yet finally defined and discussed. Revenues depend on the political will of the member states to use PRS and to pay for its service.

Ad (iii) High accuracies (in the centimetre/millimetre range) are mainly asked in surveying which represent < 1 % of the overall satellite navigation market. Positioning accuracies in 1-2 meter range are provided by the augmentation systems like EGNOS, WAAS, MSAS, GRAS and GAGAN[26] free-of-charge. As mentioned under ad (i) Glonass and/or the Chinese system could be used to replace the Galileo system in the combination with GPS (combination techniques using several frequencies are one of the main keys for getting high accuracies).

I like also to remind that the US considered these questions already in 1995 in two studies which have led to the U.S. GPS Policy Presidential Decision Directive of 29 March 1996[27]. One of the studies was conducted by the National Academy of Sciences (NAS) and the National Academy of Public Administration (NAPA)[28] and the other by the RAND Corporation[29]. The motivations cited for the study were "pressures on the defence budget, the necessity for increased civil-military cooperation, the importance of dual-use technology for economic competitiveness and conversion, and the President's interest in effective infrastructure investments." Among others, the following questions – similarly the ones we have for Galileo - were addressed:

- How should the GPS be structured and managed to maximize its dual utility for civilian and military purposes?

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[24] Glonass presently uses the so-called Frequency Division Multiple Access (FDMA) and has announced plans to change to the nowadays in all satellite navigation systems used Code Division Multiple Access (CDMA). In order words: Combining Glonass with other satellite systems is possible in one single receiver in a **simple way only if CDMA** is used.

[25] No reliable information about the deployment schedule of Compass is available. However, it may be possible that Compass may become fully operational before 2013 (Galileo FOC).

[26] EGNOS is the augmentation system in Europe - see foot note 3. WAAS is the American, MSAS the Japanese, GRAS the Australian and GAGAN the Indian one.

[27] See http://gauss.gge.unb.ca/policy/policy.html

[28] National Academy of Public Administration, National Research Council, The Global Positioning System - Charting the Future, Summary Report, Washington, D.C., May 1995

[29] Scott Pace, Gerald P. Frost, Irving Lachow, David R. Frelinger, Donna Fossum, Don Wassem, Monica M. Pinto, *The Global Positioning System Assessing National Policies*, RAND Corporation, 1995

- How should the GPS program/infrastructure be funded to ensure consistent, sustainable, and reliable services to civilian and military users around the world? Are there equitable cost recovery mechanisms that may be implemented to make the GPS program partially or fully self-supporting without compromising U.S. security or international competitive interests?
- Is commercialization or privatization of all or parts of the GPS consistent with U.S. security, safety, and economic interests?
- Is international participation in the management, operation and financing of GPS consistent with U.S. security and economic interests?
- How can communication, navigation, and computing technology be integrated to support and enhance the utility of GPS in all transportation sectors, in scientific and engineering applications beyond transportation, and in other civilian applications identified by the study?

Both studies came to the conclusion that a satellite navigation system like GPS should be considered as a "public good", as infrastructure of a country paid for by general revenues like value-added taxes on products and general taxes by (newly-creating) navigation-related industry. Therefore the recommendation was to refrain from imposing a receiver tax or special fees, since enforcing payments or fees would be difficult or impossible. Mechanism for it would be most likely in the same range as revenues thus creating also an economic niche for competing (new as well as old) systems which are free-of-charge.

In considerations of these findings of the U.S. with respect to GPS in 1995 and the failure of the PPP negotiations for the deployment of Galileo, the EU Transport Council Conclusions of Nov/Dec 2007 are justified to wait for a final decision on the business model of the operational phase until reliable and detailed technical, commercial, financial and programmatic studies are carried out based on more experiences of Galileo. This will be not the case before 2013. The anticipated schedule mentioned above seems to be appropriate. However, problems which have led to the collapse of the PPP negotiations remain most likely the same also in the operational phase; a failure can therefore not be excluded.

Forthcoming studies should have to explain, whether and how economic conditions in the world satellite navigation scene and market are now different from the ones leading to the US findings in 1995 which could indicate that there are direct commercial revenues of a satellite navigation system possible in future. To the author's knowledge there are no circumstances so far which would justify to believe this. Moreover, with the future existence of four global (Compass, Galileo, Glonass, GPS) and two regional (QZSS - Japan, IRNSS - India) satellite navigation systems competition will be even higher. None of the other systems has announced plans for direct commercial revenues. The justification for public funding of a satellite navigation system has definitely to be seen in its strategic nature (civilian as well as military) of this high-tech field and market of the future as well as in the indirect income governments will achieve by taxes from new enterprises, various related tax revenues, etc.

6. CONCLUSIONS

With the Council conclusions of Nov/Dec 2007 public governance, management structure, procurement strategy as well as overall costs and public funding were proposed by the EC and agreed between the member states.

Public sector governance of the GNSS programme is now defined; however, the role of the European Parliament has still to be clarified.

The implementation of an Inter-institutional Group consisting of representatives of the Parliament, the Council´s Presidency and the Commission (ITRE) – as recently suggested by the EP´s Committee on Industry, Research and Energy (ITRE) – contributes to transparency in the GNSS programme. Reporting was proposed to be in quarterly intervals, but could be relaxed to half-year intervals in order to minimize administrational burdens in the programme.

The request of the EP to participate as observer in the "Committee on the European GNSS Programme" is another positive aspect in getting transparency into the programme and could be easily realized.

The GSA has lost its role as supervisory authority for the concession which does not take place. ITRE has therefore proposed to abolish the GSA and to incorporate the remaining functions into the structure of the EC and/or ESA.

Two options were discussed in this note. The first one suggests incorporating all remaining functions into the programme manager's (EC) unit. The second one proposes to transfer (a part of) the GSA into a GNSS Security Agency which is needed in the programme and which does not fit properly into the structure of the programme manager. All other functions (and corresponding personnel) should be transferred to the EC (as program manager) whereby it should be discussed whether certification still could be contracted out to the private sector. Financial and other necessary efforts for implementing either option 1 or 2 should be compared to those ones in which the GSA is left as it is and where only internal re-structuring in the GSA would take place in order not to generate again additional costs. No savings are possible in case the GSA would be closed since the GSA costs including the personnel are covered by the general administrational budget of EC.

In order to come to working structures for the management structure, several actions are necessary like

- the built-up of the programme manager (unit) where additional personnel in the order of 35 staff members are required in addition to the existing ones of the EC Galileo unit,
- the built-up of ESA´s new directorate on the Galileo Programme and navigation related activities which requires the same amount of new personnel (around 30-40),
- the establishment of a Committee on the European GNSS Programme assisting the EC as programme manager, and
- the establishment of an agreement between the EC and ESA (which is a central point in the management structure) defining clear and transparent the responsibilities of the procurement agent, requirements and control measures to be put in place as the tendering procedures, appeal and dispute settlement procedures.

It is not unlikely to estimate that these actions will still require several months until autumn/end of 2008 before efficient programme structures for the European GNSS programme are built up.

Attention is required that the public side (EC, EP, Committee on the European GNSS Programme) does not over-constrain the programme which might easily transfer in delays, additional costs and uncertainties for the future. It is more than important to minimize administrational requirements and to establish now a lean and effective management on all sides.

The estimated overall FOC cost of 3.4 B€ seem to be a reasonable ceiling price based on present best knowledge estimated by various institutions/companies/industry. It contains contingencies of the order of 12 to 13%. It is the hope of the EC that the costs overrun of the IOV phase of the order of 350 M€ could be covered by the FOC budget.

The planned procurement strategy should enable competition as well as dual or multiple sourcing for items whenever possible since these are the main instruments for keeping the costs down.

Various risks are still in the programme (as it is the case in every space programme) ranging from management and procurement risks, design and development risks, deployment risks, market and operational risks as well as the ones which may come from outside. Delays of the order of up to 2 years and costs overrun of up to 25% may happen (12 to 13% are already calculated in the Contingency budget).

The business model for the operational phase has still to be studied in the next years enabling private industry to assess more accurate the possibilities of commercial revenues and gaining more experiences with the system itself. Considering the corresponding 1995 findings of the US with the GPS (mentioned in chapter 5) and the occurrence of other global navigation satellite systems over the next years, it will be more than difficult to recover direct revenues.

Nevertheless, summarizing now the new developments for the European GNSS programme, it looks that it comes now more to a sound and realistic way for building it up. Most important is the establishment of a lean and effective management where the different (political) actors do not over-constrain nor steadily and continuously intervene once the working rules are established (hopefully by autumn/end of 2008).

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