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Progress report on the GALILEO programme

INTRODUCTION

This report is in response to a request by the April 2001 Transport Council.

It takes stock of the progress of the GALILEO satellite radionavigation programme so as to enable the December 2001 Transport Council to take the decisions needed to move on to the programme development phase in full knowledge of the facts, these decisions being:

- adoption of the Regulation on the Statutes of the GALILEO Joint Undertaking;
- the release of €450 million (from the appropriations assigned to the trans-European networks) to fund the development phase.

In addition to this report, the summary and final report of the study on the financial prospects for the GALILEO programme as a whole will be sent directly to Council and Parliament.

The sections concerning the integration of EGNOS into GALILEO and the security issue are in response to specific Council requests.

1. ACTIVITIES IN 2001

1.1. Use of the €100 million released by the April Transport Council

The April 2001 Transport Council authorised the Commission to allocate €100 million to GALILEO in 2001 for the pre-development phase. This €100 million is to be used as follows:

1.1.1. €30 million for the ESA

The amount allocated to the ESA concerns studies and technical support measures for task definition and consolidation activities relating to the development phase of the GALILEO programme (detailed definition phase or B2).

These activities have been defined and followed up jointly by the ESA and the Commission, the latter benefiting from the support of the interim management structure (see point 1.4.2).

The work will break down as follows:

a. System definition

- signals definition;
- detailed system architecture, including integrity;
- interface with communications systems;
- taking into account the protection of the system and signals emitted.

b. Task consolidation and programme aspects

- Consolidation of the objectives of the GALILEO programme with a view to the updating of the "High Level Mission Definition Document";
- Certification and approval of the "Safety of Life" service;
- Definition of security requirements;
- Consolidation of the development plan and costs.

c. Experimental test bench

In order to validate the system performance objectives and the development plan, it is essential to establish full-scale test facilities as soon as possible. Test bench development has already been initiated by the ESA.

1.1.2. €70 million for to the Joint Undertaking

This amount will be allocated to the Joint Undertaking once it has been set up. It will make it possible in particular to fine-tune the definition of the different GALILEO segments (space, ground and user segments) and their implementation.

The following activities are concerned:

➤ Use of the frequency spectrum

The GALILEO frequencies were obtained following tough negotiations at the World Radiocommunications Conference in 2000. However, the frequency applications to reserve the frequencies needed for GALILEO will lapse unless at least experimental signals have been emitted not later than 2004 on the various frequency bands.

This entails defining and implementing payloads for the various frequency bands allocated for the emission of signals in space. This activity will need to be coordinated with the experimental test bench.

➤ **Detailed system definition up to the user level**

This relates to studies concerning the integration of GALILEO into the existing service infrastructures and the definition of the different components and user terminals.

At the same time, the security aspects and the integration of the resulting constraints in the system design will be defined more precisely.

➤ **Study concerning the management structures for the subsequent phases of the programme**

This activity includes the analyses and studies needed to establish a simple structure for the management of the GALILEO programme starting with the deployment phase which will be predominantly funded by the private sector.

1.2. The contracts concluded with industry under FP5 (GALILEI)

In December 2000, the Commission launched a Targeted Action on GALILEO¹. The scope of this Targeted Action is to support, in the research framework, industrial activities as preparatory actions for the Development and Validation phase.

In the framework of this call, the following tasks were identified:

- Local element definition,
- Interoperability,
- Frequency, standardisation and certification,
- Pilot projects,
- Detailed service analysis,
- Legal and regulatory aspects.

All selected proposals addressing the tasks have been integrated in a cluster called “GALILEI”. This clustering has resulted in an efficient and balanced project with a solid technical co-ordination ensuring the necessary consistency between the various tasks. In terms of industrial participation the cluster approach translates a balanced industrial repartition of work and activities by bringing together satellite manufacturers, service suppliers and users of the system.

The expected results of this research project are therefore efficiently contributing to the main objective that services provided by the GALILEO infrastructure fulfil user’s needs.

The same call has allowed to initiate several pilot projects, based on a shared funding with industry, in various domains, i.e. dangerous goods mobility (NAUPLIOS), infomobility safety critical application (INSTANT), railway operation system (GADEROS) and safety of life road driver assistance (GALLANT).

¹ 5th Framework Programme - 4th periodic Call for proposals for the specific programme “Competitive and Sustainable Growth”- OJ N° 359/23, 14 December 2000.

A supplementary activity has also started in the field of user tools for market analysis (POLARIS).

1.3. International negotiations and relations with third States

Negotiations with **USA** on a cooperation agreement based on Article 300 of the Treaty establishing the European Community are progressing steadily since the meetings in Brussels on 23 May and Washington 28-30 October. Work on a draft agreement laying down principles of cooperation remains a priority for both sides. The main concerns of the US authorities relate to ensuring GPS favourable interoperability, competition and standardisation arrangements. The Commission aims for a level playing field in GNSS overall and maintains that two systems backing each other up are today more necessary than ever to reduce vulnerability. (Commission has suggested technical discussions on system security.) GALILEO technical design has been fine-tuned facilitating thus interoperability and co-existence of the two systems. This is important for the user community and manufacturers. American manufacturers have shown interest towards GALILEO.

The negotiations on the basis of Article 300 with **Russia** slowed down in early 2001 (due to differences related to financing). However, the recent high level contacts between both parties have again raised the issue of GNSS cooperation. The Commission has relaunched the process by opening informal talks with the Russian Space Agency in November 2001. Russian Federation State Council has decided to allocate substantial funding in GLONASS maintenance for the coming decade.

Contacts with other non-member states interested in participating in GALILEO have continued.

Concerning **China** Vice-President de Palacio has had high level talks with Chinese leaders on potential GNSS cooperation in June and September 2001 (dates to be checked). A joint working group was established and met in October 2001.

A working group on GNSS was set up with **Mediterranean partner countries** and met in May 2001. Working level and/or contractual contacts have been held with **Canada, Norway, Israel, Czech Republic, Ukraine, Japan, Australia and African authorities**.

GALILEO Information seminars were held in **China** and **South Korea**.

DG TREN sponsored and participated in the Second United Nations/United States Regional Workshop on the Use and Applications of Global Navigation Satellite Systems (GNSS), organized in cooperation with the Government of Austria and the European Commission” in November 2001.

The Commission’s services are preparing new negotiation mandates for submission to Council approval in early 2002.

1.4. Programme management

1.4.1. Proposal for a Regulation on the Statutes of the GALILEO Joint Undertaking

In accordance with the requests made by the Stockholm European Council and the April 2001 Council, on 20 June 2001 the Commission adopted a proposal for a Regulation on the Statutes

of a GALILEO Joint Undertaking based on Article 171 of the European Community Treaty. This proposal is intended to ensure a single management and financing structure for the programme during its development phase (2002-2005).

The 16 October Transport Council held a first policy debate on Member State control over the Joint Undertaking, private-sector participation and the role of the ESA, culminating in the following conclusions:

Role of the MS: the Council expressed a preference for the establishment of a supervisory board composed of representatives of the Member States;

- **Private-sector participation:** Coreper will establish the framework and arrangements with a view to avoiding conflicts of interests;
- **Role of the ESA:** the Council asked the Presidency to request the European Space Agency to confirm its wish to participate in the Joint Undertaking.

The December Transport Council will adopt the Statutes of the Joint Undertaking if the European Parliament's opinion has been delivered by then.

1.4.2. Setting up the GALILEO Interim Support Structure (GISS)

The European Commission has awarded a service contract to the European Space Agency in order to set-up the GALILEO Interim Support Structure (GISS). This structure, based in Brussels, is under the supervision and the instructions of the European Commission and reports functionally to the GALILEO Programme Management Board (PMB).

The GISS initiated its work in July with a core team of 5, while it is expected that it will reach a nearly full team situation in December.

The GISS harmonises the reports submitted to the GALILEO Steering Committee and to the ESA navigation programme board and is in charge of their actual implementation. These tasks include mission and programmatic aspects, technical coherency of the programme, development of downstream applications as well as legal and regulatory issues.

The GISS will remain in charge of these activities until the moment the Joint Undertaking will reach an operational level allowing it to take over these responsibilities.

1.5. Frequencies and signals

In March 2001 the Commission's services set up a "signal task force" in which the ESA, Member States' experts and representatives of the space industry and receiver designers participate. The representatives of the national frequency agencies are associated with the work of this task force.

Following in-depth work, the latter called into question a scenario selected for GALILEO, i.e. not to use the radionavigation bands already used by the GPS.

The work carried out has made it possible to conclude that:

- it is possible, under the rules of the International Telecommunications Union, for GALILEO signals to be superimposed on GPS signals without degrading them;

- the levels of interference calculated for the different types of candidate signals have made it possible to identify solutions enabling far superior performances to be achieved for GALILEO signals at the same cost;
- a consensus has been found after six months of work on the best scenario (the baseline A scenario for GALILEO); its main characteristics are as follows:
 - better multipath resistance of open signals;
 - a lower cost for GALILEO by simplifying the design and implementation of receivers;
 - better resistance of the "Safety of Life" signals;
 - better interoperability with GPS by joint use of L5 (E5A) and L1 bands;
 - better performance of the encrypted signal in the event of emergencies.

In conclusion, the GALILEO frequency plan defined by the "Signal Task Force" makes it possible to establish a joint approach with regard to the GALILEO signal.

1.6. Activities carried out by the ESA (Phase B2)

The GALILEO Phase B2 Study contract was submitted by Galileo Industries as planned at end-May and fulfilled most of the shortcomings identified in the first submission. This allowed ESA to start the activity. Full contract signature was reached end of September.

The first study milestone is the so-called « Key Point Meeting (KPM) » which was held in the second half of October. The KPM mainly address the outcome of the Mission Consolidation and System architecture trade-off tasks. The KPM is an essential milestone in order to refine Mission and System requirements.

Furthermore, ESA also initiated work on Public Regulated Services (PRS) to complement mission consolidation tasks.

The Change Request concerning security aspects was issued on 15 August. The statement of work and requirements applicable have been produced by the GALILEO Security System Board (GSSB) and have been revised by ESA (non-classified documents only). This activity foresees a plan of work split in two phases with an intermediate milestone denominated Key-Point Meeting Security (KPM-S). After KPM-S, security related work is planned to be synchronised to the main Phase B2 work. The budget of 5 millions € is entirely financed by the budget of the European Communities.

2. RESPONSES TO THE REQUESTS FORMULATED BY THE COUNCIL IN APRIL 2001

2.1. Study of the economic aspects of GALILEO

As requested by the Council in April 2001, the European Commission has launched a study. The required outputs were :

- to give a perspective of all the phases of the project,
- to enable the longer term development of the private sector involvement in the project,
- to identify the commercial and public services to be provided by GALILEO,
- to specify the revenue flows that they could generate,
- to specify the accompanying measures required to bring this about,
- and to help clarifying the conditions for the longer term commitment by the private sector.

PriceWaterhouseCoopers Project Finance and Privatisation team, with input from Satel Conseil, Ovum, Denton Wilde Sapte, Willis Inspace and Deutsche Bank, have been engaged by the Commission to perform this activity.

This consortium is therefore advising on the commercial and public services to be provided by GALILEO and on the revenue flows that they could generate. A thorough assessment of the costing data has resulted in a consolidated set of figures serving as the basis for the overall financial envelope request. The final outcome is a business plan for the GALILEO project as a basis for getting private sector involvement through a potential PPP structure with a view to launching the next phase of the programme.

The final report of this activity has been provided by the Commission to the Council as a separate document from PriceWaterhouseCoopers.

In a second phase, PriceWaterhouseCoopers might be requested to provide further advice to support implementation of the Council's conclusions.

To perform this work, the consortium has been in contact with a range of companies and national administrations involved in the space, telecommunications and navigation sectors."

2.2. Private-sector participation in the development phase

Some 15 companies signed a Memorandum of Understanding on GALILEO in Spring 2001. This MoU brings a combined private sector contribution of € 200 million for the development and validation phase.

The actual form of the commitments of the signatories is to be defined as a function of the frame that is being set in place for the development phase. As such, direct contributions to the capital of the Joint Undertaking are possible, as well as other legal forms (framework contracts, technological contributions in kind, etc.).

The final arrangements for private-sector participation to complement the public funding should be agreed in 2002, once the Joint Undertaking has been established.

2.3. EGNOS Integration into GALILEO

2.3.1. Mandate

The European Community Transport Council stated in its 11 April 2001 Resolution on GALILEO that “*The optimal integration of EGNOS² into the GALILEO programme must be effected in close collaboration with the EOIG³ in accordance with a transition programme that will be completed around 2015. To that end a detailed proposal concerning the technical, operational, financial and institutional aspects of that integration will have to be submitted by the interested parties as soon as possible. As long as necessary, separate financial arrangements for GALILEO and EGNOS have to be implemented.*”

This resolution calls on all parties interested in EGNOS to provide a detailed integration scenario covering all aspects as soon as possible.

In order to facilitate this task the Commission’s services detail in this proposal two possible scenarios about how to integrate EGNOS into GALILEO for the benefit of all interested parties and stakeholders.

The ESA executive recently presented a major input for this position paper in its PBNav Paper ESA/PB-NAV (2001) 29.

This proposal will be presented to the European Tripartite Committee for endorsement and will also be thoroughly consulted with EOIG.

2.3.2. General considerations

The Commission’s services take the view that there are effectively two integration possibilities for EGNOS into GALILEO.

The first option would be a continuation of an operational EGNOS as GPS/GLONASS overlay into an operational GALILEO environment.

The second option would be a pre-operational integration of EGNOS signal in space into GALILEO with combined operational validation and certification.

These two options are detailed below.

2.3.3. Integration Scenarios

Option 1: Integration of an operational EGNOS into an operational GALILEO:

EGNOS will reach its advanced operational capability in the year 2004. At that date the system still needs to undergo operational validation in the various modes of transport before being able to enter into a certified operational service, probably around early 2006.

According to the GALILEO High Level Mission document it is intended that EGNOS will continue to provide GPS augmentation when GALILEO will become operational in 2008.

² EGNOS, the European precursor to Galileo, is a satellite radio navigation system that relies on the American GPS and the Russian Glonass and monitors their integrity, thereby warning the user in a very short space of time of any malfunction that could affect the quality of the signal

³ EOIG: EGNOS Operators and Infrastructure Group.

EGNOS would then serve as part of a Global Navigation Satellite System in which users could rely on two satellite constellations (GALILEO and GPS) that would each provide its own integrity information.

From a structural point of view it would make sense to integrate the EGNOS service provider into the GALILEO service provider to guarantee consistency in the service provision and to benefit from synergies.

This scenario requires EGNOS to be operationally validated and certified after the current ESA « ARTES 9 » programme will have expired. Two independent operational validations and certifications for EGNOS (estimated costs could sum up to a total of several hundreds of MEURO⁴) and GALILEO will be necessary.

Operating costs for EGNOS are estimated to total € 25 millions per year⁵.

The full benefits of an operational EGNOS will mainly depend on three factors:

- 1) Duration of the transition from terrestrial navigation aids to GNSS
- 2) Reduction potential of the terrestrial infrastructure in an EGNOS environment.
- 3) Costs for the receiver equipment.

Taking all that into account, an operational integration of EGNOS into GALILEO would have the following advantages and disadvantages:

A. Advantages:

- Early European operations based on augmented GPS/GLONASS signals.
- EGNOS services would stimulate the market for integrity services thus facilitating the introduction of integrity services based on GALILEO.
- Operational EGNOS would deliver experience with certification and operational validation of satellite navigation in the “Safety of Life” market also envisaged for GALILEO.
- The risk for later certification and operational validation of GALILEO would be reduced.
- Europe would participate in worldwide standardised satellite-based augmentation navigation that would also be provided in the US, Japan and potentially other regions of the world.
- Europe would be in a position to provide an operationally certified integrity service for GALILEO and GPS.
- EGNOS is independent from GALILEO development and related risks.

B. Disadvantages:

- High costs for certification and operational validation for EGNOS and later on for GALILEO and no direct Community funding for a purely operational EGNOS system.

⁴ Estimation from EOIG

⁵ Source: EC Geminus study

- Additional transponder leases on satellites necessary to fulfil redundancy requirement.
- Long transition phase from terrestrial navigation to full GNSS.
- EGNOS service on GPS would be possibly in competition with GALILEO «Safety of Life» service for users that only require integrity service on one constellation.
- Business model relies mainly on aviation market, which is reluctant to introduce pure «Space-based Augmented Service» technology when GALILEO will arrive a few years later.

Option 2: Integration of a pre-operational EGNOS into GALILEO:

An alternative to scenario 1 could be to integrate a pre-operational EGNOS with no operational certification and validation into the current GALILEO architecture and certify some years later GALILEO and EGNOS together.

This would entail that EGNOS infrastructure would be deployed. A basic EGNOS signal would be transmitted to attract potential users and make them familiar with the integrity technology. Programmatically and financially EGNOS would become part of the GALILEO programme as soon as a basic EGNOS signal would be available.

This option would face the following advantages and disadvantages:

A. Advantages:

- One single operational validation and certification for all new GNSS components (GALILEO, EGNOS, local elements) thus leading to cost savings for EGNOS and GALILEO and no necessity for additional funding for operational EGNOS validation and certification.
- Consistent and predictable European concept for GNSS enabling world-wide users to rely on one single transition scenario.
- Cost reduction for the early operational phase of EGNOS possible.
- No additional satellite transponder necessary.
- No receiver re-equipment.
- Possibility to revert to option 1 at any time in case of GALILEO difficulties.
- Benefits from reduction of terrestrial infrastructure for aviation better predictable.
- Reduced transition costs and risks.

B. Disadvantages:

- No early operational benefits from EGNOS. Operational benefits would be delayed by 4- 6 years.
- No early experiences with operational validation and certification.
- The operational EGNOS service provision would depend on the GALILEO program.

2.3.4. Technical integration of EGNOS into GALILEO :

According to the GALILEO Mission High Level document EGNOS would remain the European regional integrity component for GPS augmentation whereas GALILEO would provide in parallel its own integrity.

On-going activities still need to confirm the market for two high performance integrity services for Europe and the integrity concept for GALILEO.

Institutionally EGNOS would become part of the GALILEO organisational framework.

2.3.5. Conclusion :

The option 1 necessitates, however, significant public funding for a long time after the completion of the ongoing ESA ARTES 9/ EGNOS activities.

In case the public sector will be unable to guarantee the required funding for option 1, option 2 could provide for a viable alternative. This solution would allow adapting EGNOS to the GALILEO services and a re-use of either the entire infrastructure or the technology know-how would enable Europe to fulfil its contribution to GNSS. It would thus provide for a unique European navigation transition strategy including the outlined cost saving potential, however with a delayed certified operational phase for EGNOS. In any case the economic success of EGNOS will depend on quick transition from terrestrial infrastructure to EGNOS technology.

2.4. Safety aspects

The first results of the work of the GALILEO Security System Board (GSSB) which helps the Commission as regards the security aspects of GALILEO may be summarised as follows:

2.4.1. General considerations

Three aspects are concerned as regards the security of GALILEO:

- Security with regard to misuse of the GALILEO signal for hostile purposes.
- The intrinsic security of the system itself with regard to an interruption in service, since the system comprises material components (infrastructures, ground stations, satellites, physical installations), as well as links and interfaces (communications, computer links, ...) and the signal itself..
- Data security, i.e.protection of information with regard to private operators, will raise the same questions as with mobile phones.⁶.

2.4.2. General security policy

The following principles - which concern intrinsic security and security with regard to misuse - have been adopted by experts:

⁶ Traceability, archiving, judicial access rules, protection of data and information with regard to hacking, etc.

2.4.2.1. Space segment

Unlike the GPS, the space component would not be protected against explosions or space debris which are rare at this altitude. On the other hand, uplinks and downlinks will be protected.

2.4.2.2. Ground segment

The various components (monitoring stations, control stations, mission centres) and the links between the various centres and stations will be protected. The infrastructures will be regarded as sensitive as they are components of a space system. Files will be protected to prohibit access, modification, copying, saturation or hacking of any kind. For all the space and ground components, security will concern both infrastructures and staff.

2.4.2.3. User signal

There are two families of signals for GALILEO:

- An open signal available for all users. In an emergency, this signal will be denied (scrambled) to prevent misuse.
- An encrypted signal accessible only to authorised users (police, sensitive and controlled infrastructures ...) in particular when the open signal is scrambled; encrypting is governmental and will be developed by some Member States (France, Germany, the United Kingdom, Italy and one or two other countries with the know-how).

2.4.3. *European political authority*

As indicated in the Commission communication of 22 November 2000 (COM(750) final), it is important that the public authorities should retain control over the system in order, in particular to be able to take the urgent decisions needed in a crisis. The GSSB considers that a European political authority should be established this end.

2.4.4. *GALILEO security regulation*

The Commission's services are preparing a proposal for a Regulation to define the security rules which will apply to all the structures and staff working on the GALILEO project.

2.4.5. *Security constraints*

Measures will be taken to prevent the misuse of GALILEO. Geographical access denials will be possible very rapidly.