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COMMUNICATION FROM THE COMMISSION

Galileo

Involving Europe in a New Generation of Satellite Navigation Services

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EXECUTIVE SUMMARY

This Communication sets out a strategy to secure a full role for Europe in the development of the next generation of Global Navigation Satellite System (GNSS) and so full opportunity in the related market. The central recommendation is that Europe should develop a new satellite navigation constellation, combined with appropriate terrestrial infrastructure: Galileo.

The EU is faced with a formidable challenge but also with a major opportunity in respect of global satellite navigation which is becoming central to all forms of transport and many other activities. These systems will play a crucial role in creating the integrated European transport system that is crucial to support the single market. Further, EU Member States have public obligations to provide safe navigation services and other public services (for example, search and rescue) and GNSS can be the most cost-effective means of achieving this.

The issue is not, therefore, whether Europe should rely on satellite navigation systems for the future, but what economic benefits, including jobs, it would gain from playing a full role in development of the system, and what degree of control it will have over the systems on which its safety critical services will depend.

Last year, the Commission identified the following problems with continued reliance on third countries' systems[1]:

- There are serious problems of both sovereignty and security if Europe's safety critical navigation systems are out of Europe's control. Furthermore, the present systems cannot fully meet civil users requirements in terms of performance.

- There is a need to ensure that European users are not at risk from changes in the service or excessive future charges or fees: faced with a dominant position or virtual monopoly, it would be difficult to resist such charges and perhaps impossible to develop alternatives quickly.

- The capacity for EU industry to compete in this lucrative market (a potential global market of €40 billion by 2005) would be seriously constrained. (Europe's capacity to compete in the market for services could be undermined if it did not have equal access to the technological developments in the system itself).

The strategic choice

Work by the Commission over the last year has focussed on two key areas: identifying the scope for joint approaches with the US, the Russian Federation and others, and clarifying what a European system would look like, and how much it would cost. With a clear view on both these points, the EU is now in a position to make the key choices.

As the communication makes clear, an urgent decision is needed: the US is committed to developing GPS and reinforcing its global dominance. They already have a head start. Unless Europe gives a firm political commitment now to developing a European system, to be in place at the same time as the next generation of GPS, it will simply be too late.

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[1] Communication 'Towards a Trans-European Positioning and Navigation Network – including a European strategy for Global Satellite Navigation Systems (GNSS),' COM (98) 29 final of 21 January 1998

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The shape of Europe's 'best buy' is now relatively clear:

- It must be an open, global, system, fully compatible with GPS, but independent from it, with a significant role for the Russian Federation.

- It should be based on medium Earth orbit (MEO) satellites and will cost between €2.2 and 2.9 billion;

- It should be developed as a public private partnership, with significant funding at European level, and reliance on creating new revenue streams.

The Commission considers that this option provides a means of achieving Europe's strategic, commercial, transport and employment objectives at an acceptable cost. It is therefore clearly preferable to the 'zero option' (relying on the existing military constellations).

Scope for international co-operation

In last year's communication, three broad options were identified:

- a joint global system with all the major players;

- the EU developing a GNSS with one or more international partners (particularly, the US or Russia);

- independent development by the EU of its own system.

The Commission recognised that, in principle, joint development of the next generation GNSS was likely to be the most cost-effective option, but made clear that co-operation would need to satisfy certain conditions: firm guarantees against disruption, full participation in the future design, development and operation of GNSS, a full EU role in the control of the system, and an opportunity for European industry to compete in all segments of the market. The Council endorsed this approach and requested the Commission to intensify contact with, in particular, the US and the Russian Federation. Following extensive contacts, the Commission has now reached the following conclusions on the scope for joint development.

The US is not willing to share control of GPS (primarily for military reasons) though it is positive about co-operation in certain technical areas. They also recognise that two complementary systems (GPS + Galileo) will increase overall robustness, allowing satellite navigation and precision timing to be employed in more critical applications (e.g. as sole means of navigation for certain operations) or more difficult areas (e.g. in cities). It is proposed that this co-operation should be pursued.

The Russian Federation is offering, effectively, full partnership in developing a new international civil system from the basis of the present GLONASS. The principal advantages of this approach would be that Europe could, through use of Russian know-how in satellite operation and control, develop a robust Galileo more quickly than otherwise. This would also allow shared use of the valuable GLONASS frequency allocation.

The recommended approach is, therefore to develop a Galileo which is global in coverage from the outset and independent from the US GPS, but fully interoperable with it. This would be open to participation by other partners. In particular, there could be major advantages for Europe from Russian involvement, if this can be established on a satisfactory basis. Within the constraints of interoperability with GPS, it would exploit new, state-of-the-art capabilities,

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allowing the development of new applications, making the overall GNSS robust and remedying certain shortcomings of the present GPS (e.g. poor availability in urban areas and the northernmost latitudes, unpredictable temporary gaps in coverage, including over the European continental landmass).

What system to choose

The proposal for Galileo is based on a core constellation of MEO satellites, combined with appropriate infrastructure and terrestrial systems to provide the integrated service required from the Trans-European positioning and navigation network. This approach represents minimum technical risk, since existing systems use this technology, particularly if co-operation with the Russian Federation can be established on a satisfactory basis. The approach would need to be global from the outset if Europe is to reap the benefits of a global presence and provide a global market for the system and its applications.

Finance

The key question is how Europe should finance a system. As long as the US continues to provide its basic GPS signal free of charge, it is clear that European public spending would be needed for the development of Galileo. A three point financing strategy is proposed:

- substantial financing at European level, through the EU Budget, notably the Transport TEN, and through ESA;
- establishment of revenue streams, which is likely to require regulatory action ; and
- developing a public private partnership (PPP), to deliver complementary finance and value for money. However, firm political decisions are required to give industry the confidence to invest.

As far as EU funding is concerned, it is suggested that around €500 million (10% of the total budget for transport TENs proposed by the Commission in Agenda 2000) could be made available from the TENs Transport budget (ESA envisages being able to contribute a similar amount). A further €120 million or so for research and development activities could come from the 5th Framework Programme, with further funding possibly available from a 6th Framework Programme.

A number of possible revenue streams have been identified, notably the idea of a levy on GNSS receivers, together with charges for a restricted access service which could provide guaranteed levels of performance, liability cover, etc. These could contribute significantly to financing Galileo if the Council is minded to put the appropriate regulation in place.

A PPP for Galileo could provide complementary finance, improve project design and ensure overall value for money. Crucially, it would confirm private sector commitment to the project. In particular, the need to encourage take-up of the service in order to generate income and reach profitability would provide a powerful mechanism for ensuring users' needs are given central importance, while a PPP structure will help keep costs under control since much of the risk of construction cost over-run would normally fall on the private sector. It would also reflect the fact that Galileo combines public service and commercial aspects. The aim would be for the project to approach self-financing in the operational phase when recurring costs (operations and replenishment) would amount to between €140 million and €205 million per year.

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The ideal approach would be to set up a full PPP as soon as possible. This would be the design-build-operate model. But this will require a significant amount of further work on performance requirements, risk allocation and revenue streams. Each of these areas needs to be explored in co-operation with the private sector. This would be a central part of the Definition phase of the project.

Organisational issues

Galileo would be a unique project, involving a wide range of political, economic, security and commercial interests. It will need an organisational structure that reflects this unique character. A number of issues affect the organisational structure. A PPP carries implications for organisational structure: the aim will be to establish a 'vehicle company' to carry out the deployment and subsequently operate the system. However, some central aspects of Galileo fall firmly within the public domain. Involving international partners in Galileo would imply that they would need to be part of decision-making structures.

Three basic levels are identified:

- Political/strategic, providing overall direction, and handling main international negotiations. It is recommended that the EU institutional framework would be used for strategic decisions. The Commission should then lead the international negotiations, initially with the US and Russian Federation, on the basis of guidelines adopted by the Council.
- The Programme Management Board which would be responsible for ensuring the project is completed, with financial decisions, and for establishing the terms of any tender, and have the contractual relationship with the PPP vehicle company. In the operation phase, this would become the Galileo administration.
- The PPP vehicle company.

But not all decisions need to be taken now, and the project should now pass to the definition phase, financed by public money, in which the work necessary to put in place the final structures, especially the PPP, is carried out.

Recommendations

The Community institutions are, therefore, invited to:

- take a firm political decision to develop Galileo, as described above, which represents minimum technical risk and best value for money, in order to guarantee Europe's strategic interests;
- endorse the three point financial strategy: substantial European level financing, development of revenue streams, and a PPP approach. In particular, endorse Galileo as a key priority under the TENs, to benefit from funding on a multi-annual basis (estimated €500 million over the period 2000-2006)
- recognise the need for negotiations and technical discussions with third countries. The Commission should be requested to negotiate suitable agreements on GNSS on the basis of guidelines to be adopted by the Council.
- agree the organisational approach for the project definition phase, with urgent efforts to establish the permanent structures identified.

1. INTRODUCTION

In its conclusions of 17 March 1998 on the European Commission's communication 'Towards a Trans-European Positioning and Navigation Network – including a European strategy for Global Satellite Navigation Systems (GNSS),' the European Union (EU) Council of Ministers requested the Commission to present recommendations on the future European approach to global satellite navigation.

The Commission was requested to intensify its contacts with important international partners such as the United States of America (US) and the Russian Federation, so as to assess the potential for joint development of a system that meets the Community's requirements. The Commission was also asked to accelerate its work to examine the option of developing an autonomous European satellite navigation system.

In January 1999, the European Parliament adopted a Resolution on the Commission's Communication[2]. This, inter alia, called upon the Member States of the EU to convene a European Space Council at the Head of State or Government level and requested the Commission to present as soon as possible a coherent strategy for the development of a Trans-European positioning and navigation network.

Since March 1998, an unprecedented number of meetings of the major actors of a future satellite navigation system has taken place, involving several hundred of the most important players in the field. Equally, a dense schedule of meetings with international partners has been followed. This Communication reports on the results of the work carried out this last year and proposes a European strategy for the medium term, together with an implementation programme.

The intention is to enable the Community institutions to take the necessary decisions on implementing a European contribution to the next generation GNSS. In this Communication, the European project that will result has been provisionally called Galileo.

The Communication therefore includes a set of policy conclusions, and the list of supplementary actions that need to be accomplished over the next few months. The Commission will also soon produce negotiating guidelines in order to have the appropriate international agreements in place in time. The three key points are to agree that Europe should develop Galileo as soon as possible; to agree the general architectural design of Galileo; and to establish an appropriate financing framework, with maximum private sector involvement as early as possible (Public-Private Partnerships) and earmarking of the necessary public funding. Developing an adequate regulatory, operational and project management structure will be a major priority for the next stage.

2. THE CHALLENGE FACING EUROPE

2.1. The issues at stake

The EU is faced with a formidable challenge but also with a major opportunity.

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2 A4 – 0413/98, 13 January 1999.

Strategic considerations: At present, there are two core Global Navigation Satellite Systems – the US GPS and the Russian Federation's GLONASS – and GPS currently dominates the market. GNSS is becoming central not only to all forms of transport, but also to many other activities. For example, manufacturing industries and the service sector increasingly depend on GNSS for positioning and/or precision timing. This reliance raises important questions of a strategic nature, including for the Common Foreign and Security Policy, especially if the core systems are not under European control or influence.

Europe is now in a position to decide whether to develop a new system. The challenge is to guarantee Europe's strategic needs without excessive cost or risk. By contrast, failure to act would strengthen the present US market dominance and leave Europe entirely dependent on the US for many security-related matters.

Galileo gives Europe clear opportunities for strengthening political ties with other countries. The US and Europe have already recognised that co-operation could be mutually beneficial, at least in the field of civil applications, and co-operation with the Russian Federation could also have considerable mutual benefit, strengthening the Partnership and Co-operation Agreement[3]. Other countries may also become partners in the venture, increasing international co-operation and supporting global market development and both inward and outward investment.

The transport dimension: It is clear that satellite navigation will increasingly play a fundamental role in transport in the future. GNSS will be part of an intelligent infrastructure, helping to ensure safety[4], streamline traffic operations, reduce congestion and environmental damage and support multi-modal development. Advanced navigation systems are a prerequisite for efficient transport management and sustainable mobility which are themselves critical for economic growth.

Further, under different international Conventions, EU Member States have public obligations to provide safe navigation and certain other public services (for example, search and rescue). A coherent Galileo programme, integrating, as appropriate, other systems, can ensure cost-effectiveness and potentially allow considerable economies to be made in public spending.

Galileo could also remedy shortcomings of the present GPS and GLONASS constellations which cannot guarantee the reliability and availability which is indispensable for transport and vital economic operations. Further, one potential advantage of having two independent but compatible space navigation systems (GPS + Galileo) is that each system acts as a backup to the other, so that it becomes possible to base safety-of-life applications solely on satellite navigation. The satellite service can thus supersede certain terrestrial infrastructure, resulting in further substantial savings on operation and maintenance.

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3 Agreement on Partnership and Cooperation, signed on 24 June 1994 by the European Union and the Russian Federation. It represents a commitment from both sides to promote and encourage political, economic and scientific partnerships.

4 The GNSS Strategic Study, carried out for the Commission in April 1998, noted, for example, that combined transport-related communication and GNSS navigation data could be directly beneficial to rail, assisting in train control and collision avoidance, especially where it is uneconomical to provide the electrical power needed for passive sensor beacons or track-side vandalism is a problem.

The economic/industrial dimension: The Commission Communication of January 1998 outlined the vast array of potential applications for a satellite timing, positioning and navigation system and the economic opportunities these offer (a potential global market of €40 billion by 2005[5]). Almost every day new applications are being added to the list of services which are based on GNSS. The challenge is to ensure that Europe can take a fair share of the global market, and the related jobs. User demand for GNSS-based goods and services is increasing quickly. The GPS hardware market in Europe was estimated in 1997 at $228.7 million and is anticipated to grow to $960 million in 2004[6]. Annex IV gives further detail on future market prospects. Further, establishing a fully robust GNSS infrastructure would accelerate the development and introduction of a wide variety of value added applications for all transport modes over large geographical areas, thus bringing the socio-economic benefits which result from these services much earlier[7]. In this respect, Galileo can contribute significantly by bringing new levels of performance, increasing GNSS service availability and providing guarantees and liability cover which will both support the general market growth and attract particularly those customers requiring high standards.

The Galileo debate over the last few months has demonstrated the project's potential for developing interest and increasing awareness for commercial applications. The European Parliament has emphasised the advantages of creating a 'general culture of using space applications technologies' which could be ensured through the European participation in the development of GNSS.

It is recognised that, with European involvement in the evolving signal structure and the possibility of adapting the programme to users' future requirements, Galileo should help industry stay at the leading edge of the development of future applications. Moreover, the existence of a competitive system to GPS would ensure that no unilateral decisions on charging could be taken which would destabilise industrial planning.

Over the last decade, space has increasingly become an area for commercial exploitation. Telecommunications and broadcasting are two examples. There is fierce competition in the deregulated fields and major players are increasingly joining forces to generate economies of scale. In Europe too, the space industry is restructuring to take on the challenge that it faces in global competition. Giving a political direction for Galileo would support the space and defence industries in their restructuring. The political lead could bring added value, helping ensure Europe's position in this strategic sector.

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5 The ESA-funded GNSS-2 Comparative System Studies have identified a number of important political benefits from a Galileo over and above a GPS-only baseline, in part due to the improved performance of a joint GPS/Galileo system. These include an additional €40 billion from sales of equipment, and €40 billion from value added services for European firms over the period 2005-2023. Other analysis has focused on benefits to transport users, although the increasing integration of navigation and communication services will fuel the already significant growth in non-transport applications. Between the major transport modes, expected total benefits are in the region of €18 billion over the first five years of operation of Galileo.

6 Report by Frost and Sullivan, quoted in Global Positioning System Market Projections and Trends in the Newest Global Information Utility, International Trade Administration, Office of Telecommunications, US Department of Commerce.

7 The implementation of many value added mass market applications, most notably for road transport, would be accelerated, with market saturation reached 10 years earlier (GNSS-2 Forum Technical and Financial Group Report, December 1998).

There is also an increasing need to develop synergies between the existing national space agencies and with ESA and to establish the right co-ordination with the wider European political institutions (EU, WEU[8]). Galileo could provide the catalyst to allow an exemplary division of labour between the different actors and institutions to develop.

Employment: The presence of European industry in this high technology field, which is beginning to develop exponentially, will help to secure and augment employment. It is estimated that putting the satellite navigation infrastructure into place would support 20,000 jobs; its operation would create 2,000 permanent jobs with considerable new employment opportunities in applications (hardware and services)[9].

Regulatory issues: Increasingly, European regulatory requirements could envisage the use of information systems relying on positioning and/or timing signals. This could, for example, be the case in the future for electronic fee collection[10], in the environmental field or in agricultural or fisheries surveillance. A Galileo would allow for the necessary certification to take place (something which is not possible with current systems), thus ensuring regulators' and users' confidence in the adequacy of such systems. Regulatory action could thus underpin Community objectives.

2.2. Timing considerations

An early decision is important, as a rare window of opportunity is open. The US has taken its basic decisions on the design of the next generation of GPS satellite (block IIF), including the definition of a second civil frequency, and will be deploying the new satellites in the next decade. If Europe waits, the new block IIF will reinforce the present GPS dominance and the market will have adopted GPS as the standard. Realistically Europe could then play only a supporting role.

By contrast, action now would permit Europe to develop an improved service (signal structure, power levels, etc) which, though interoperable and fully compatible with GPS, would give Europe a real possibility to penetrate the market. Galileo could be deployed considerably quicker than otherwise, making it more competitive, if Europe's approach were to build on GLONASS, provided that serious attention is given to building confidence in the system and promoting it globally. The challenge is to act decisively and in time.

A decision has to be taken as early as possible in 1999, establishing a medium-term policy for Europe's involvement in the next generation satellite-based positioning, navigation and timing systems. No decision is, by default, a decision to exclude Europe

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8 Western European Union, composed of Belgium, France, Germany, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain and UK. It also has a number of Associate Members (Iceland, Norway, Turkey), Associate Partners (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia), and Observers (Austria, Denmark, Finland, Ireland, Sweden)

9 Current estimates within the ESA GNSS-2 comparative study suggest a Galileo project would also increase employment in equipment production and sale from less than 25,000 (based on GPS alone) to around 70,000 (GPS + Galileo) in 2008. In total, therefore, it is anticipated that, by 2008, in the region of 100,000 jobs in direct, indirect and induced employment depend on going ahead with Galileo.

10 Commission Communication on electronic fee collection, COM (98) 795 final of 21 December 1998.

from the development of a strategic sector and the definition of new global standards, with serious consequences for strategic, economic, industrial, employment and transport policies; a deferred decision will also mean that US dominance will be further consolidated, so Europe will find it considerably more difficult, and probably impossible, to enter the market, and will essentially have to accept the standards set by the US. A long-term EU commitment needs to be given to generate the development of market applications and support private investment in the system.

3. Recent Developments and Preliminary Conclusions on the Strategic Choices for Europe

In last year's communication, three broad options were identified:

- a joint global system with all the major players;
- the EU developing a GNSS with one or more international partners (particularly, the US or Russia);
- independent development by the EU of its own system.

Extensive contacts with our international partners have made it possible to narrow down these options considerably.

3.1. Joint development of a system: potential for co-operation with the US

In view of this considerable challenge facing Europe, the March 1998 Council requested the Commission to explore with the US the possibility to develop a common system. Three sessions of discussion took place with the US (in May, July and November 1998). It rapidly became clear that the US could not consider future joint ownership and a full role for Europe in the control of the basic 24-satellite GPS constellation (primarily because of military considerations). Co-operation with the US would therefore need to be based either on reliance on the existing US-controlled GPS or on developing a GNSS based around two complementary satellite navigation systems, one GPS and one European/international. Besides clarifying and reducing the number of options, the useful discussions with the US administration allowed progress to be made towards establishing principles which could form the basis of a future co-operation agreement.

Baseline for US-EU co-operation

From the US perspective, in both cases, fruitful co-operation with Europe would only be possible if Europe accepted the GPS standard positioning service (SPS) and signal structure as a basis for all civil applications of the future GNSS. This would avoid proliferation of different systems and also ensure the policy stability which is important for industrial reasons. If Europe committed itself to GPS as a global standard, the US would consider European participation in the process of developing and modernising the GPS system, as well as an appropriate EU role in civil operations and management. The US would also consider making a statement of intent to provide continued access to the GPS signal, free of direct user charges, to discontinue Selective Availability and to observe an agreed notice period prior to any planned withdrawal of the GPS signal. If the EU decided to invest in developing and implementing a constellation which complemented GPS, the joint EU/US objective could be

to establish a fully interoperable, global system consisting of two independent components. There is consensus between the US and Europe that two independent systems would improve the robustness and the possible performance of the overall GNSS system and might potentially allow sole use as a means of navigation for certain safety-related activities. Such an orientation could have considerable implications for the way Galileo develops and for its cost-effectiveness.

3.2. Joint development of a system: the Russian Federation

Discussions with the Russian Federation took place in May, July and October 1998. The Russian Federation has proposed a joint approach to develop a state-of-the-art global navigation satellite system and appears willing to meet the requirements outlined in the Commission's communication of January 1998, and endorsed by the Council, allowing for joint ownership and management of the future constellation. The Russian authorities have developed a transition plan for GLONASS which would include its transfer to civil control and its promotion as a system for civil use[11]. It would initially be an independent complement to GPS and would gradually evolve into Galileo (progressively improving the robustness and performance of the overall GNSS system).

The principal advantages of this approach would be that, if co-operation developed satisfactorily, Europe could, through use of Russian operational know-how, develop Galileo in a much shorter time than otherwise, and that it would allow the valuable GLONASS frequency band to be used, despite the present strong competition for access to scarce radio frequencies, especially for commercial telecommunications. It would not limit options for the future.

In this scenario, a gradualist approach would be pursued, beginning with a political framework to facilitate initially the exchange of know-how between industrial actors, while possible operational arrangements are explored. This would be set in the context of the Partnership and Co-operation Agreement, taking full account of EU security interests, and the objectives of the Common Foreign and Security Policy.

3.3. Japan as potential partner for a joint development of a system

Japan has issued a joint statement with the US to recognise GPS as a global standard. This is designed primarily to encourage a market-led development of applications based on satellite navigation. However, it does not undermine possible alternative approaches to GNSS-2 or preclude R&D efforts. Although Japan is thus concentrating at this stage on GNSS-1, they are increasingly showing interest in Europe's attitude to a possible GNSS-2. Building on the constructive dialogue which has developed to ensure interoperability between the respective GNSS-1 space-based augmentations (EGNOS and MSAS), Japan may become interested in being involved in a Europe-led development of a Galileo space segment. This could thus help reduce calls on the European public purse. A decision to go ahead with Galileo should be accompanied by continuing discussions on the possibility of Japan taking a significant role in it. Exploratory discussions should therefore rapidly take place with appropriate ministries and

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[11] The launch on 30 December 1998 of three new satellites demonstrates the Russian Federation's commitment, despite economic pressures, to maintaining GLONASS. A further launch is being planned. A modernised GLONASS satellite with longer life expectancy has been designed but further improvements are foreseen through integration of Western standards.

agencies on possible future co-operation. Industrial co-operation appears to provide an early opportunity to develop the relationship.

3.4. Other countries and regions as potential partners for a joint development of a system

As regards other countries, several have indicated interest in co-operating with the EU to obtain benefits from GNSS-1 and to consider GNSS-2. Such co-operation could remedy deficiencies in present navigation infrastructure, create the full global market opportunities that have been recognised and support effective development of industrial co-operation. It should, however, be clear that the nature of this co-operation is unlikely to reduce significantly the cost of building Galileo but could contribute to global interoperability and potential market opportunities and revenue streams.

Initial contacts in this framework have been made with the Central and Eastern European countries, Turkey, Switzerland, Iceland, countries in the CIS, Africa and South America, as well as Canada, Australia, India, China and Korea. For industrial, strategic and political reasons, as well as for the safe, effective and efficient transportation of goods and people, it is vital to promote Europe's GNSS approach with third countries, not least the candidates for accession, so that they are able to contribute to its success. Europe can then develop and export a new global standard.

3.5. GNSS-2 Forum

In order to fulfil the March 1998 Council remit, the Commission set up the GNSS-2 Forum[12] which mobilised most of the relevant European actors in the field (over the period July to December 1998). The work of the GNSS-2 Forum, as well as the results of a number of studies, and in particular the preliminary findings of the ESA GNSS-2 Comparative System Studies, have contributed to shaping the opinion and recommendations of the Commission.

The most relevant conclusions of the Forum suggest that the future GNSS system should be based on a combination of GPS and a global European-led component (Galileo). The latter should be open to the inclusion of complementary contributions from third countries and organisations (subject to industrial, political, military and security considerations). The analysis of the different criteria for GNSS-2 points strongly towards the need to develop a system that can provide at least two levels of service. These should include a basic public service, provided free of charge as long as the equivalent US GPS service is free, and a service designed for users who require a high level of service guarantees (for example in terms of the availability and integrity of the signal). The development of a public-private partnership (PPP) approach was seen as a priority: the Forum recommended analysing more concretely how best to attract private investment. It was felt that the system should be global from the start in order to allow full development of the global market, to meet the needs of global industries (e.g. aviation and the maritime sectors; financial institutions and others

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[12] The GNSS-2 Forum included leading experts from industry, European institutions and organisations, radio-navigation service providers, user communities and academia and supported the development of the Commission's thinking on institutional and legal matters, technical and financial evaluation of different approaches, civil/military and security issues and user requirements. The Forum met in plenary and group sessions and produced a final report in December 1998.

dependent on precision timing) and because no partners were identified wishing at this stage to develop matching regional contributions.

3.6. The European Parliament

The Commission Communication of January 1998 was considered by the Parliament which, on the basis of a comprehensive report, adopted a Resolution on 13 January 1999. This recognised that European industry had previously suffered from a lack of clear political direction and commitment in the space sector by the European institutions and welcomed the Commission's paper, considering that a strategy had been needed for years. Parliament called on the Member States to give clear decisions at Heads of State or Government level on strategic, technical and budgetary guidelines and on the timetable for GNSS-2. It equally asked the Commission to conduct in-depth negotiations with international partners, to lead European negotiations in the international fora for satellite orbital positions and frequencies assignment to satellite navigation services and to provide a regulatory framework for the creation of an internal market for applications of European space technologies, whilst stressing that GNSS should, as far as possible, be financed through models of private/public partnerships and user contributions.

3.7. Rejecting the 'Zero Option'

All scenarios need to be compared with the zero option: a conscious decision to abstain from having a European presence in the core space segment of the future GNSS. This would mean reliance on the US GPS system and, potentially, the Russian Federation's GLONASS or any new system developed by other states.

Clearly, a European decision to concentrate on applications and augmentation systems and abstain from moving into satellite-based navigation would be welcomed by the US since this would confirm the present and ensure the future dominance of GPS. Moreover, European research and Trans-European Network money might be concentrated on GPS augmentation (including through systems such as EGNOS) and developing GPS-based applications in the intelligent transport sector and in other domains.

The arguments outlined above in chapter 2 'The Challenge for Europe' speak against the abandonment of the European ambition to participate in the control of the space segment. However, it is clear that public spending would have to be carefully estimated, planned and controlled and that the private sector would have to take, where reasonable, part of the risk of developing Galileo. Besides looking at technical features and organisational issues, the main thrust of this Communication is therefore to make recommendations ***to ensure that Europe can afford to be present in the future Global Navigation Satellite System***.

Conclusion: The 'zero option' leaves Europe without adequate assurance that its political, strategic, economic, employment, industrial, security, space and, of course, transport and other interests are preserved.

Drawing together the results of discussions with the US and Russian Federation, the recommendations of the GNSS-2 Forum and on the basis of the views of the Council and the Parliament, the Commission has concluded that a Galileo, having the following characteristics, should be developed:

– It would be independent from the US GPS, but complementary to it, and

interoperable with it.

- **It would be open to other partners to participate. In particular, there could be major advantages for Europe from Russian involvement, if this can be established on a satisfactory basis.**

- **Within the constraints of interoperability with GPS, Galileo would exploit new, state-of-the-art capabilities in a civil system, allowing the development of new applications, making the overall GNSS robust and remedying certain shortcomings of the present GPS (e.g. poor availability in urban areas and the northernmost latitudes, unpredictable temporary gaps in coverage, including over the European continental landmass).**

- **It would be global in coverage from the outset, to ensure effective independence and to provide a global market for the system and its applications. Galileo would include a restricted access service.**

4. SYSTEM ARCHITECTURE AND TECHNICAL FEATURES

This chapter considers which architecture would be best suited to meet the demands of users in a cost-effective manner. It represents the first outline of Galileo.

4.1. Performance requirements

For aviation and maritime users, there are already international performance requirements for navigation systems. Essentially, a world-wide requirement of 10 metre horizontal accuracy is the minimum standard which Galileo would need to meet if it is to be accepted as an inherent component of a world-wide radio-navigation system[13].

Other users have not developed similarly precise demands which have the backing of regulation. There are also potential users whose needs have not been defined, although the market potential has been identified.

The GNSS-2 Forum identified certain broad performance requirements for Galileo, including that it would need to provide approximately equivalent performance to the next generation of GPS (Block IIF) if it was to be regarded as a credible system[14], that the space segment should not attempt to provide all navigation solutions[15] and that additional navigation-related communications capabilities on board the satellites would be useful.

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[13] Users can directly determine their navigation solution (three-dimensional position, velocity and time) in real time when receiving at least four signals from four different satellites, without referring to other systems..

[14] This has been interpreted as meaning global landmass and coastal water coverage at not less than 9.1 metres horizontal and vertical accuracy, without local area augmentation, 95% of the time. Higher levels of service should be available from the system through integration with terrestrial augmentation.

[15] A comprehensive navigation network for Europe, with the required levels of robustness and integrating satellite-based and appropriate terrestrial technologies, will be designed and proposed by the Commission as a European Radio-Navigation Plan, once decisions have been taken on the European involvement in GNSS.

During the project definition phase, the input of user groups, potential service providers and public authorities will be vital. Only after this can precise mission requirements be set and final decisions made on the required terrestrial and space infrastructure.

The aim of the European radio-navigation strategy must be to meet set performance requirements with regard to security and safety cost-effectively. There will inevitably be satellite-based components and terrestrial elements, supporting overall system robustness. The indications from experts and accepted by the Commission in defining an approach to European involvement in GNSS are as follows.

The definition of the architecture is based on achieving global coverage, providing access to mass market applications, with a good basic level of safety for European transport operations, but with a minimum space infrastructure (allowing for augmentations to be developed where required to meet more stringent safety demands or for dedicated commercial applications).

There are four types of orbit for navigation satellites which could provide a homogeneous signal in space for a global service area (cf. annex II a)[16].

The optimal system definition should take into account the different strengths of the different orbits to ensure performance in line with safety requirements and user demands, including the provision of integrity data. Precise recommendations will be made through the ESA comparative study. However, at the present stage, it appears clear that the core constellation for Europe is likely to be a **Medium Earth Orbit (MEO)**, representing low technical risk and known performance capabilities.

The MEO approach was adopted by both the US and the USSR for the systems they developed. It has proved very efficient and has been retained for later generations of the two systems, including GPS Block IIF and GLONASS M. This option, therefore, represents minimal technical and industrial risk, in particular if Europe and the Russian Federation can build on each other's respective strengths and experience.

The wide area augmentation services being developed by the US, Japan and Europe (WAAS, MSAS and EGNOS respectively) provide integrity checks and differential correction[17] to the GPS signals; EGNOS in addition similarly augments GLONASS. They also provide a ranging signal.

To date, the work led by ESA and with the close involvement of industry has focused on two broad options:

- a core constellation of 21 MEO, which would come close to meeting European requirements. Integration of GPS and local area augmentation in a total system approach could guarantee the European requirements, and

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16 GNSS-2 Forum Technical and Financial Group Report, December 1998

17 Integrity can be defined as the level of confidence given to users that the calculated position corresponds to the data provided – it is based on ensuring users are alerted to errors through a warning message provided within a specified time; differential correction means reducing the main sources of positioning error which result from the propagation of radio-waves through the ionosphere

- a core 36 MEO constellation, which would meet European requirements fully and independently.

Users will require real time information on the health of the constellation (i.e. certainty that the signals are correct). The integrity message might, at least in part, be delivered from the core MEO constellation but it is considered at this stage that a complement of between 3 and 9 GEO and/or IGSO satellites, which might include the EGNOS satellites, will be needed[18]. The optimal integration of ground networks, including those developed for EGNOS and, if suitable agreements are reached, GLONASS, is also foreseen. The Galileo work programme will also need to cover a strategy for the problem of space debris.

While this is only a preliminary sketch of Galileo, the basic decision on European involvement in GNSS can already be taken since sufficient details of constellation parameters and fairly accurate budgetary implications are already known. In addition to positioning, navigation and timing, it is anticipated that hosting limited navigation-related communications capabilities on Galileo could make safety critical services more reliable and generate revenue streams[19].

4.2. Security issues

There are clear security requirements relating to the physical protection of vital infrastructure (such as control centres and communication networks) as well as with regard to the provision of accurate navigation signals in times of tension or war. Further, protection against spoofing and other forms of misuse and interference with the signal in space needs to be ensured. Conversely, it must be possible to deny use of the system to enemy forces in a war situation. The system design will need to take these general requirements into account. In addition, an interference monitoring structure and an interface with the military will need to be established. The Commission intends to have further exploratory discussions with a view to identifying appropriate partners and structures for this interface, in accordance with the recommendations of the study carried out for the Commission[20] and in the light of international discussions and negotiations, and will make proposals as soon as feasible in the framework of the Community common foreign and security policy.

An approach favoured by experts in the GNSS-2 Forum was to develop a controlled access service. They envisaged that there would be universal access to a basic signal for mass-market applications. There would also be a controlled access service, using a second signal, with guaranteed availability and accuracy. It could also provide users with liability cover in case the system failed to meet performances specified. The controlled access could further satisfy

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18 To be confirmed during the definition phase of the ESA GNSS-2 comparative study. The GNSS-2 Forum Technical and Financial Group Report, December 1998, identified a 36 MEO + 9 GEO constellation as a baseline to meet user requirements (9.1 metres horizontal and vertical accuracy, without local area augmentation, 95% of the time).

19 The technical and financial group of the GNSS-2 Forum considered these issues in depth. It was concluded that the options of hosting navigation payloads on communications satellites (i.e. 'piggy-backing') and vice versa were unrealistic. Limited navigation-related communications capability could, by contrast, be feasible and provide added value.

20 Civil-military interface for GNSS, January 1999

international commitments such as for safety-of-life services. For example, search and rescue operations could depend on this service in any circumstances. The service is seen as key to attracting private sector involvement in GALILEO and generating revenue streams. In times of serious tension or conflict, this service would, however, be restricted to authorised categories of subscribers.

All these security issues have implications for system design and need to be resolved before the test and validation (*tendering and construction*) phases of GALILEO can begin (altering the design and requiring re-deployment of satellites and modification of the ground segment need to be avoided). Preliminary costings for this are included in the financial section 5.1 below.

4.3. Requirements of GNSS Ground Network

The function of the GNSS ground segment is to provide integrity monitoring, orbit determination and timing synchronisation and management of overall system operation. The ground segment for EGNOS, currently being implemented as part of the Trans-European positioning and navigation network, has been developed, to the greatest possible extent, to be reusable in a European GNSS-2 constellation. Additional ground stations may need to be deployed outside the EU to guarantee good global performance. In order to guarantee the system performance, physical security requirements must be taken into consideration. Examples may include restricted access to buildings, dedicated communications networks, suitable power levels and encryption of ground - satellite links.

In addition to the basic Galileo infrastructure, including the related ground segment, the potential will exist to enhance the performance to attain higher precision and other dedicated services, in particular through use of appropriate terrestrial infrastructure. Together, these will contribute to the Trans-European positioning and navigation network, providing robustness, meeting special demands from particular categories of user in defined areas and providing service where satellite technology cannot provide a cost-effective solution. In essence, the intention of the proposed European involvement in GNSS is not to attempt to achieve sole means of navigation for all phases of navigation from the basic satellite system alone. Rather, the GNSS architecture must be seen as a prime component of the positioning and navigation networks and integrated for optimum cost-effective use.

4.4. Signal structure

The development of a new satellite constellation, designed for the twenty-first century, allows Europe to consider improving present signal structures to meet future user demands. The GPS signal is widely recognised by users as a satisfactory structure although it is not guaranteed and not always available. A European development would need, from the mass-market user point of view, to deliver a signal compatible and interoperable with GPS. Used together, the modernised GPS[21] and enhanced European signals should provide a better service than is

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[21] On 25 January 1999, US Vice President Gore announced a new GPS modernisation initiative in a programme costing $400 million. This involves adding two new civil signals to future GPS satellites. The initiative is seen by the US administration as part of an on-going public-private effort. The second civil signal will be located at 1227.60 MHz, along with the current military signal, and will be available for general use in non-safety-critical applications. A third civil signal, for safety-of-life applications, will be located at 1176.45 MHz, within the current aeronautical radio navigation spectrum.

available from GPS alone. In order to optimise the European signal and reduce susceptibility to jamming and spoofing, careful selection of frequencies[22] and transmission power will also be required. While the subject is highly technical, the essence is that discussions are beginning with the US and with European industry to define the parameters within which Europe can develop an enhanced signal structure. This will include necessary work on global standardisation of timing and geodetic references.

Conclusion: Galileo should provide, as a minimum, three-dimensional performance over landmasses, accurate to better than 10 metres horizontally, providing a universal independent time reference on a global basis. A core MEO constellation is considered to be the most cost-effective and technically proven approach for the initial deployment and provision of a basic service. The constellation needs to be fully integrated into a cohesive Trans-European positioning and navigation network. A good level of security and a controlled access signal are also key features. Adequate long-term spectrum allocation and full interoperability and compatibility with GPS are critical.

5. FINANCIAL ASPECTS

Given the present policy of the US to provide the basic GPS signal free of charge, it would be illusory to imagine that Galileo could be developed and provided exclusively by the private sector. As in a number of major infrastructure projects in the context of the Trans-European Networks, considerable public funding will need to be found. For Galileo, this would apply particularly for the definition and test and validation phases, when basic research, concept testing and development of the space segment would be carried out.

This section of the paper sets out a three point financing plan:

- substantial financing at the European level, through the EU Budget, notably the Transport TEN, and through ESA;
- establishment of revenue streams, which is likely to require regulatory action ; and
- developing a public private partnership, to deliver complementary finance and value for money.

5.1. Estimated costs

The cost of the space segment and the required ground infrastructure for a basic public service will depend on the satellite constellation. There is still a range of options to be evaluated before the optimum constellation to meet performance requirements can be defined. However, it is already possible to give a fairly accurate indication of the potential cost of Galileo[23].

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22 Subject to agreements with the Russian Federation and the US, Galileo might transmit on two of the current GLONASS frequencies and one or more GPS frequencies. Use of frequencies covered by the European filings in the ITU will also be considered.

23 The figures are summarised in Annex III b.

Work led by ESA and with close involvement of industry has focused on costing two broad options (cf. section 4.2)[24]:

- a 36 MEO and 9 GEO constellation, costing around €2.2 billion over the period 1999-2008, and
- a 21 MEO and 3 GEO constellation, costing €1.6 billion. Integration of local area augmentation[25] in a total system approach could guarantee the European requirements.

A satisfactory co-operation agreement with the US might, in principle, allow both sides to consider reduced satellite constellations which together would guarantee the levels of service required by each party. Further, co-operation with the Russian Federation in design and implementation of Galileo could reduce costs.

Estimates for the introduction of a controlled access service, together with security and safety certification, suggest a need for an additional budget of between €600 million and €750 million.

Thus the total cost of Galileo over the period 1999-2008 is currently estimated at between €2.2 and 2.95 billion, depending on extent of joint operation with GPS and use of terrestrial systems. Not all of this needs to be public funding if a PPP approach is adopted.

Recurring costs (operations and replenishment costs corresponding to the options described above) amount to between €140 million and €205 million p.a., beginning in 2008. However, some cost savings should be possible when current alternative navigation aids can be decommissioned.

5.2. Sources of public funding for Galileo

The case for a public contribution to Galileo has been made above. In principle, it would be possible for this to be financed from national budgets. But Galileo is a key part of the Transport TENs[26] and the Common Transport Policy and an essentially Trans-European project, bringing direct benefits to all Member States (helping them meet their public service and international obligations with respect to providing navigation aids). This constitutes a strong case for funding at EU level.

At the European level, a number of possible financial sources can be identified:

- First, for infrastructure development and deployment, the Commission has, in the context of AGENDA 2000, proposed some €5.5 billion for the Trans-European Networks. With

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24 N.B. the estimates are based on the assumption that research and development, deployment of the ground segment and operational costs are constant for all options.

25 Local area augmentations required to meet performance targets for Galileo (reduced constellation) amount to an estimated €200 million (based on equipping 250 major cities).

26 GNSS is clearly identified as a prime element of the positioning and navigation network and a project of common interest in the present TEN-Transport guidelines (Decision N° 1692/96/EC of the European Parliament and of the Council of 23 July 1996 on Community guidelines for the development of the trans-European transport network; OJ. L 228 of 9 September 1996).

the recent adoption of the common position on the revised TEN financial regulation, multi-annual indicative programming should soon become possible[27]. This should create the stable environment needed to encourage private investment and support market development. The Commission's intention would be to propose in its future multi-annual programme to earmark around €500 million (which is 10% of the budgetary envelope proposed for the Trans-European Transport Networks) for Galileo and to report regularly to the Council and the European Parliament on the progress of the project. This is in line with the Commission's objective of giving greater relative priority to intelligent transport systems.

- Second, within the overall budgetary envelope envisaged for the 5th Framework Programme[28], the Commission considers that around €120 million could reasonably be found for Galileo. The lifetime of the 5th Framework Programme is limited to 2002, and a continuation of funding beyond 2002 would be proposed, subject to evaluation of the 5th Framework Programme.

- Third, for co-operation with the Russian Federation and other countries of the former USSR, the Commission's TACIS programme offers possibilities of support in the fields of training and conversion of industries from military to civil purposes.

- Fourth, ESA would, in the context of its institutional mechanisms, potentially be able to mobilise funds of the same order as under the TENs.

Thus, in total, up to €1.25 billion could be mobilised on the European level for a Galileo programme for the period 2000-06, compared to a total cost of €2.2 to 2.95 billion spanning 2000-08. On the level of the EU, this would not involve the creation of a new programme but would be done by earmarking certain sums in established Community programmes. ESA would have to launch a new programme.

On the basis of the estimates described above, a further sum of between €950 million and €1.70 billion would be required (before taking account of potential EU funding in 2007-8 which is outside the current financing period). A number of options exist to mobilise this additional money:

- First and foremost, the identification of potential revenue streams could attract the involvement of the private sector in Galileo. This might also allow the EIB, (and, in the case of a Euro-Russian co-operation, the EBRD), to finance part of the project through long term loans;

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27 This should respond to the Opinion of the Parliament's Committee on Budgets that the lack of clear political direction and commitment from the European institutions had a detrimental effect.

28 Proposal for a decision of the European Parliament and the Council covering the 5th Framework Programme of the European Union for research, technical development and demonstration activities (1998 to 2002), COM (97) 142 final. Use of the expertise of the Joint Research Centres (in particular, the Space Applications Institute) and actions under the thematic programmes 'improving the quality of life and the management of living resources' and 'promoting competitive and sustainable growth' as well as the horizontal programme 'confirming the international role of Community research' may be involved.

- co-operation with other countries may allow sharing of costs between international partners; and

- a number of Member States may be able to contribute individually; in particular to ensure that aspects of the European GNSS which are security related are adequately handled.

5.3. Potential revenue streams enabling public-private partnership

Revenue streams will reduce the need for public subsidy and facilitate PPPs. Furthermore, the Parliament requested the Commission to investigate new and even unconventional methods to ensure that future users pay for GNSS services they receive[29]. The Commission has, therefore, considered a number of potential sources of revenue streams.

- First, a possible revenue source relates to different levels of service (two or more signals from the space segment, one generally available, and one or more offering higher levels of service based on controlled access). Different receivers or smart cards would need to be developed for the different levels of service:

  - level 1 service to the mass market
  - level 2 a certifiable service
  - level 3 safety of life and security-related services.

  It is envisaged that level 1 services, consistent with present US policy on the equivalent standard positioning service of GPS and the Russian Federation's civil GLONASS signal, would be available free of charge. Should the US and/or Russian policy on charging change, the European position could be revised.

  Levels 2 and 3 would be controlled access services, available to subscribers in return for certain fees. In some cases, the use of these services might be mandatory, such as in connection with electronic fee collection for access to infrastructure or monitoring fishing activities, freight and coach transport and road safety services. It may be noted that IMO is requiring internationally-registered ships to carry GNSS equipment from 2000 and GNSS is an integral part of the CNS/ATM concept adopted by ICAO[30].

  Levels 2 and 3 could be made even more attractive if liability cover was provided for the services subscribers received. This would in a way represent a form of insurance which would allow Galileo users to rely on services in a way which they could not do using the basic signal. Similarly, the fact that level 2 and 3 services could be certified for safety-critical and similar high-performance tasks (in a way that GPS could not) would constitute a marketable asset. Insofar as Galileo allows existing ground based air navigation facilities to be replaced and provides a better and more reliable service to airlines, it can be expected that airlines will contribute to the revenue stream.

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29 Opinion on the Commission's Communication of 21 January 1998 by the Committee on Budgets.

30 Communication, Navigation, Surveillance/Air Traffic Management

- A second possibility would be a levy on receivers for all satellite-based radio-navigation services. This would need to be introduced throughout the EU and be applicable to all receivers sold in or imported into the EU. The advantage of this levy would be to apply also to the mass-market (such as equipment for in-car-navigation, leisure activities, etc) and would therefore also cover level 1 equipment. This would be entirely in line with the general Commission philosophy of marginal infrastructure cost charging and could be limited to very small sums. Issues of user acceptability would have to be dealt with by showing a combination of cost saving, and improved service availability particularly in urban areas. Funds received could contribute, for example, to the cost of operating and updating the system once in place. Levies are already used in a large number of Member States for certain products, inter alia, for recording equipment, photocopiers and video cassettes. Equally, certain services, such as public television broadcasting, are also funded through mandatory user charges. A levy of €20 on receivers would lead to receipts of €140-205 million annually and could go a considerable way to filling the financing gap for project construction and development[31]. It would also be conceivable to introduce, but probably more difficult to implement, an annual operating license fee for the reception of satellite navigation signals.

- Equally, the private sector could generate revenue through wide-ranging applications, facilitated by the integration of communication and positioning, including dedicated navigation-related commercial and high accuracy services and integration of safety-related and security-critical payloads. This may also include some dedicated communications payloads on some satellites. A number of these functions could be used to comply with public service obligations (such as search and rescue). A 'shadow toll model' may be a way of guaranteeing revenue streams to a private operator. Clearly, giving Galileo additional capabilities to support such services will have costs that need to be compared with the extra revenue generated.

Annex IV gives some tentative market forecasts for Galileo, which indicate the broad prospects for revenue from the sources identified in this section. A number of these revenue streams, such as introducing levies and making certain uses of Galileo mandatory, depend on regulatory decisions; others, such as controlled access and encryption, depend on the definition of the technical characteristics of the system. Moreover, a number of other possible revenue streams may only be identified over time since the market for satellite-applications is growing exponentially. Industry will, therefore, need to work further on this, in the context of the overall financing package, while the public sector will need to address the related regulatory decisions.

5.4. Establishing a public private partnership

As in other TEN projects, there is significant scope for attracting private investment to develop parts of the infrastructure, provided potential revenue streams are clearly identified and there is a clear allocation of risks, which may involve Government guarantees. One aim should be for public sector funding to be largely replaced by private funding by the operational phase.

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[31] Assuming that by 2010 around 50% of new cars are equipped with a GNSS-based positioning device, and with around 14 million car sales in Europe annually, a levy of €20 would raise €140 million per year.

A PPP for Galileo could provide complementary finance, improve project design and ensure overall value for money. In particular, the need to encourage take-up of the service in order to generate income and reach profitability would provide a powerful mechanism for ensuring users' needs are given central importance, while a PPP structure will help keep costs under control since much of the risk of construction cost over-run would normally fall on the private sector. It would also reflect the fact that Galileo combines public service and commercial aspects.

A PPP is therefore the recommended approach. Indeed, this would be fully in line with the priority given up to now to such an approach. The Commission Communication on PPPs[32], which was broadly endorsed by the Council and the Parliament, sets out a number of important recommendations that are relevant for Galileo. These include:

- that private sector involvement should begin at as early a stage as possible, so they can participate in project design;
- that the public sector should seek, as much as possible, to specify project requirements in terms of outputs (service levels) rather than detailed technical specifications;
- the most effective structure for a PPP normally involves a specially created vehicle company, clearly accountable for project delivery, and with the management autonomy to run an efficient project; and
- that risk should be allocated according to scope to control them. This would, for example, mean that the private sector should be responsible for construction cost over-runs, while the public sector would be responsible for cost increases caused by regulatory changes.

These general principles need to be applied in a way that takes full account of the unique features of Galileo, including the public service component (safety of life services) and the security dimension.

The ideal approach would be to set up a full PPP as soon as possible. This would mean the design-build-operate model but a significant amount of further work will be required in the following areas:

- more precise specification of performance requirements, based on users' needs;
- identifying risks, and how they should be allocated, so that private sector investors can make a commercial judgement on the risk/reward ratio;
- identification of revenue streams, which means both more precise assessment of overall market potential and market segments likely to be willing to pay for a restricted access service, and a commitment from the public sector to take the regulatory action necessary to secure these revenue streams (e.g. the levy).

Each of these areas needs to be explored in co-operation with the private sector. This would be a central part of the definition phase of the project, which is described more fully in the next section. If this ambitious approach does not prove viable in good time (for example, if

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32 COM (97) 453 final of 10 September 1997

the public sector is unwilling to put revenue streams in place), a more traditional model (with a Programme Development Office running the project through conventional public works contracts) would be a possible fallback for the initial stages. The Programme Development Office would be disbanded once the vehicle company was in place for the deployment and operational phases. It should be noted that, while the Commission is promoting the setting up of a PPP and a vehicle company, it would not engage itself in commercial business activities (these are not provided for in the Treaty).

Conclusion: As long as the US continues to provide the basic GPS signal free of charge, public money will be needed to allow Galileo to be developed and provide a similar, free basic public service. However, a number of potential revenue streams have been identified, some of which depend on public regulatory action. The Commission will investigate, together with ESA and the EIB, the potential for setting up a vehicle company already in the initial phase of the project. If this is not immediately possible, because of lacking public commitment to ensure the necessary framework conditions for revenue streams, a two stage approach would be proposed: the first, preparatory, stage would depend essentially on public financing (TEN, Community Research Framework programmes, ESA and possibly national contributions) disbursed through a Project Development Office (risk would be shared through a tightly controlled cost contract with industry); the second, implementation, stage would imply much higher investment and commercial risk for the private sector.

6. ORGANISATIONAL FRAMEWORK

6.1. Designing, building and operating Galileo: basic principles and immediate decisions

The Commission's Communication of January 1998 summarised the roles and responsibilities which should be included in a GNSS organisational framework. The GNSS-2 Forum has further refined the work on these questions. Bearing in mind the Community approach of separation of regulatory and operational functions and the intention to build as much as possible on existing bodies and structures, the Commission is proposing the following preliminary conclusions (Annex I) sets out, in schematic form, the stages of project development, which are referred to in the remainder of this section).

It is, in this context, important to note that, for a number of questions, no immediate answers need to be given.

- With the decision to go ahead with the Galileo programme, the only firm commitment that needs to be taken is to set up the appropriate structures for the definition phase (i.e. up to December 2000).

- At the same time, the organisation of the remaining phases needs to be prepared. Here, the Commission's clear intention is to promote a PPP and to undertake everything, including regulatory proposals, to make this possible, ideally from the beginning of the development stage, but in any case before the deployment phase.

- One of the immediate actions necessary is to ensure that appropriate frequencies are available.

6.2. Strategic Aspects

The overall aim is to ensure that a robust structure is in place to take strategic decisions, oversee international negotiations, and control compliance of Galileo with international, Community and national regulations and policies. It is proposed that the EU institutional framework be used for this purpose, with the Commission providing the necessary input to the other institutions. This is a pragmatic choice: given the wide range of sensitive political, international, economic, industrial and security issues that will need to be balanced, only the EU institutional structures (and not exclusively the first pillar) appear suitable.

The Commission (in certain cases, together with the Member States) should represent EU interests at the international level on the basis, where appropriate, of mandates from the Council. This might include negotiating global standards and ensuring interoperability and compatibility between different global and regional systems. This might then mean taking a central role in discussions on GNSS signal structures, a global methodology to achieve certification, a global liability regime, and in ensuring a global integrity monitoring network[33].

The GNSS High Level Group[34] has proved useful over the last years and would have an important role in steering the Galileo programme: i.e. giving overall direction to the programme, developing and monitoring the application of a European Radio-Navigation Plan[35] and ensuring that strategic considerations, including those related to security[36], are kept in view. This might include policy on the Galileo controlled access service. The Commission would ensure that an appropriate consultation platform exists for users so that policy recommendations reflect user demands [37].

6.3. The development phase

In order to ensure tight control on costs and effective use of public resources, considerable attention needs to be given to project management. A sound and stable structure needs to be established, identifying specific roles and responsibilities.

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33 For cost-efficiency, the ground network under definition for EGNOS should be integrated with Europe's needs for GNSS-2. Further, appropriate political choices of location of infrastructure are important. It is, therefore, proposed that the Commission includes this aspect in its discussions with third countries (cf. paragraph 2.4).

34 The High Level Group was set up under Council Resolution 94/C 379/02 of 19 December 1994; OJ C 379 of 31 December 1994.

35 Providing expert input on the development of an appropriate network of terrestrial and satellite-based systems, fully taking into account the capabilities of different components and the need for safe and cost-efficient transition in accordance with Article 17 of the Trans-European Network Guidelines.

36 cf. GNSS-2 Forum, working group 3, report on security issues.

37 It is envisaged that the user group established under the Commission's GNSS-2 Forum should develop into a permanent users' forum

One important element of this would be to examine the possibility of the EU and ESA, together with any other contributors, pooling financial resources (c.f. annex I). The purpose of this would be to ensure that Galileo is run from the outset as a single integrated project. Advice on this will be sought from the EIB.

A *programme management board*, consisting of the Commission, ESA, national space agencies and other investors, would need to be set up, to put in place the vehicle company through public tender; in the period before the vehicle company is in place, it would approve choices of contractors and monitor compliance with contracts.

The overall execution of the project would be managed and carried out by a vehicle company which might include the primary industrial contractors of the Galileo project. This would act in accordance with a contract (possibly to design, build and operate the system) a key element of which would be the financial provisions relating to public subsidy and availability of revenue streams. It would, in principle, be responsible for any cost overruns.

In the definition phase, before the vehicle company is set up, the programme management board would need technical support. Since this stage is imminent, this could be provided by a technical task force, which might consist of experts from ESA, national space agencies, the Commission, potential service providers and, as required, other organisations.

If it is not possible to set up the vehicle company in time to manage the subsequent phase (i.e. development) of the project, the technical task force would need to be given more formal status, perhaps as Programme Development Office. Its role would be to co-ordinate planning and development of the space and ground infrastructure. The office would need to ensure that user demands and requirements for development of applications, as well as the possibilities for integration with local area systems and GNSS-1 infrastructure, are important service drivers and are fully taken into account in the Galileo project.

The Programme Development Office would be disbanded once the vehicle company was in place.

6.4. The Operation phase

6.4.1. Galileo management

To manage the operation of Galileo, the Commission would propose a small public structure in the form of a Galileo Administration. This would, in essence, be the successor of the Programme Management Board, responsible for ensuring the operation of Galileo, while contracting out actual operations. This would have to be established by Council decision as it would need to have legal personality in order to deal, for example, with liability issues. Such a permanent structure should boost public confidence and encourage industry to develop applications (so facilitating private investment and revenue streams).

While the size of the Administration and the tasks to be carried out are not yet fully defined for Galileo, the equivalent structure should be in operation, initially for EGNOS, by the end of the year 2000[38].

Tasks which might be assigned could include liaison with the different international organisations[39] involved in GNSS exploitation. It might also have a role in establishing an international integrity monitoring network and establishing appropriate relationships with providers of specific augmentation services, such as in the northernmost latitudes. It could also accept responsibility for peacetime co-ordination and liaison, as appropriate, with defence and security organisations, including NATO and the WEU, the Conference on Security and Co-operation in Europe, Interpol and Europol, and ensure respect of arrangements related to nuclear missile and non-proliferation regimes. In practice, its role would then involve management of encryption related to the controlled access service and the definition of responses to possible security incidents, including real time dissemination of information related to interference. With respect to liability, the Administration would be responsible for dealing with any claim relating to Galileo.

6.4.2. Galileo operation

The Commission considers that the private sector could, by way of concession, perform the main functions of a Galileo operator. If the approach to establish a PPP to design, build and operate the system is accepted, this function would be carried out by the same vehicle company responsible for putting the system in place. The vehicle company would then have responsibility for running the system on a sound economic basis[40], and integrating new technology, where appropriate, to improve services and adapt to new user demands. It would also be possible to contract out operation of the system to the private sector even if earlier stages do not involve a PPP.

6.5. **Securing Radio Spectrum**

Securing radio spectrum availability is a pre-condition to implementing Galileo and ensuring its interference-free operation.

Frequency allocation decisions at the global level are taken at World Radiocommunications Conferences (WRCs), organised under the auspices of the International Telecommunication Union (ITU) with its 186 Member Countries. European positions for WRCs are developed and negotiated within the framework of the CEPT (European Conference of Postal and Telecommunications Administrations) which

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38 If this time scale is not possible, the EGNOS Operations and Infrastructure Group currently being established should be able to assume the management responsibilities for EGNOS. In the case of EGNOS, however, there is currently no plan for a vehicle company to operate the system, so the EGNOS equivalent of the Galileo Administration would have a wider role.

39 It might thus benefit from the wider membership and ties of these organisations under international agreements.

40 Charging policy might be subject to approval by the Galileo Administration on the basis of Community guidelines and regulatory acts; fee collection would be the responsibility of the operator under concession.

comprises 43 European countries and therefore potentially leads to harmonised frequency allocations beyond the Community borders[41].

It is essential to develop a common European position so as to ensure that the frequency requirements for GNSS and Galileo are recognised and met within ITU/WRC as well as in the framework of the CEPT. As described in the recent Green Paper[42], there are wide-ranging and increasingly conflicting interests and a large number of actors involved in the preparation for the WRCs. The Commission would therefore recommend that, with regard to CEPT, consideration be given to reaching political and legal agreement through European Parliament and Council Decisions. This would follow the precedent set in the case of the harmonised introduction of mobile and satellite personal communications systems in the Community[43].

Further, especially as CEPT is in a minority within ITU, education and awareness actions will play a vital role in securing the frequencies that will permit Galileo to come into service, as well as in generating the potential market for Galileo. Alliances with like-minded countries and blocks should thus be sought for the WRCs.

As the US is also particularly concerned about protection of present radio-navigation satellite frequencies (GPS and GLONASS) in view of the forthcoming discussions at WRC 2000[44], there is an opportunity for co-operation and agreement which should be taken into account in establishing a mandate for international GNSS negotiations. In advance of this, early technical discussions with the US may be critical to defining a jointly acceptable approach and protecting European industry's opportunities in GNSS with new equipment and service design. Similar considerations apply with the Russian Federation, especially if Galileo is built jointly, using the GLONASS frequency band.

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41 The Community has the status of observer within ITU/WRC and counsellor to CEPT, providing information on the Community policies and their spectrum requirements. See further information in the Communication from the Commission to the European Parliament and Council on the World Radiocommunications Conference 1997 (WRC-97), COM (97) 304 final, 18 June 1997, and Communication from the Commission to the European Parliament and the Council on radio frequency requirements for Community policies in the context of the World Radiocommunications Conference 1999 (WRC-1999), COM (1998) 298 final, 13 May 1998.

42 Green Paper on Radio Spectrum Policy in the context of European Community policies such as telecommunications, broadcasting, transport and R&D; COM (1998) 596 final, 9 December 1998

43 Decision N° 710/97/EC of the European Parliament and Council Decision on a co-ordinated authorisation approach in the field of satellite personal-communication services in the Community, OJ L 105/4, 23 April 1997. Decision N° .../98/EC of the European Parliament and Council on the co-ordinated introduction of a third generation mobile and wireless communication system (UMTS) in the Community. Under these Decisions, CEPT is mandated to harmonise frequencies and authorisation conditions for UMTS and S-PCS; where work by CEPT or the implementation by the Member States is not satisfactory, further action at the Community level shall be taken.

44 The next WRC will be held in Istanbul between 8 May and 2 June 2000 (WRC-2000). One item on the agenda is allocation of spectrum for GNSS and other radio-navigation satellite services. CEPT has provisionally accepted the need to protect the current spectrum for radio-navigation satellite services.

6.6. Regulatory Co-ordinator

Generally, international law provides a framework for regulation of critical activities (e.g. relating to safety, industrial standards, environment and implementation of public policy) which is implemented in more detailed national legislation. For navigation, a regulator is necessary to ensure that systems and related services meet the legal performance requirements set, most notably for safety. At this stage, decisions on GNSS navigation, positioning and timing regulation clearly remain at national level or within the Community and international entities which are under definition (e.g. EASA[45]) and regulatory audit conclusions will need to be referred to the national regulators for approval.

Consideration needs to be given to whether there is a need, beyond the already existing co-ordination function that the Commission has, to set up a European GNSS Regulatory Co-ordinator, taking responsibility for the development of standards, where required (for example for certification or type approval), for Galileo and other parts of the Trans-European Positioning and Navigation Network[46]. In some cases, this may require the creation of new centres of expertise to develop standards[47]; in others, existing bodies will be able to support the work. The standards developed could then be incorporated into regulation by the appropriate bodies (e.g. ICAO, IMO, ISO, CENELEC, IEC, EUROCONTROL and ETSI). The Regulatory Co-ordinator will also be able to offer system performance monitoring so that Member States can be assured that their obligations are satisfied. This structure would also have an important role to promote the introduction of harmonised regulatory performance requirements across transport modes and between user groups.

The role of regulatory co-ordination can, at this stage, be performed by a specialist group of national experts nominated by the Member States, with the support of observers, as required, from other organisations and disciplines (e.g. national regulators; relevant international and Community regulatory entities; European standardisation bodies; agriculture, Customs and fisheries authorities; security-related activities organisations and third countries). It will monitor the work of the Programme Management Board.

A future Regulatory Co-ordinator might, at a later stage and particularly when the Galileo Administration becomes established and needs regulatory support, be empowered to develop mandatory standards to be implemented by all Member States to

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45 Draft recommendation for a Council Decision authorising the Commission to start negotiations with a view to establish a European Organisation responsible for civil aviation safety, SEC 2152, 16 December 1996. While it is noted that, in the field of civil aviation and safety regulation, the emerging European Aviation Safety Authority (EASA) is mode-specific, input from EASA will be an important element in the definition of the GNSS safety policy.

46 Including wide and local area augmentations making use of the satellite-based infrastructure (e.g. differential systems, such as DGPS, DGLONASS and Eurofix)

47 This conclusion was drawn in a study carried out on behalf of the Commission and entitled 'Study to Devise a Legal/Certification Framework for a Satellite-Based Navigation and Positioning Service (CLAIM GNSS),' September 1998.

satisfy the objectives of the Trans-European Positioning and Navigation Network. This would need to be set up in a way that does not conflict with the Treaty.

Conclusion: the following organisational structure is proposed:

For strategic decisions to be taken at EU level, with the Commission taking its usual role, supported by the GNSS High Level Group.

during the preparatory and implementation phase

an appropriate programme management structure through a Programme Management Board supported initially by a technical task force, and subsequently granting a concession to a Vehicle company;

in the operations phase,

a small GALILEO Administration, working with the vehicle company to manage the provision of satellite-based navigation services and guarantee performance, as well as ensuring peacetime defence and security co-ordination

for regulatory issues

a GNSS Regulatory Co-ordinator to develop mandatory standards to be implemented by all Member States to satisfy the objectives of the Trans-European Positioning and Navigation Network.

7. THE FEASIBILITY OF, AND POSSIBLE PARTNERS FOR, A JOINT DEVELOPMENT OF A SYSTEM: CONCLUDING AGREEMENTS

Negotiations will be necessary in order to conclude agreements with international partners, including potentially those hosting terrestrial infrastructures. The Commission will propose negotiating guidelines in each case, tailoring the content and scope to the nature of the co-operation envisaged with the different countries (industrial, political and security issues). The aim will be to ensure that Europe's interests are safeguarded in the international field, as requested by the Parliament in its January 1999 Resolution.

In the immediate future, only two decisions - to open negotiations with the US and the Russian Federation - will be sought from the Council. Further technical discussions will continue to take place whilst the Council is considering the proposed recommendations for decisions and the negotiating guidelines. With other countries, such as Japan, further exploratory talks are necessary.

As to the US, the Commission will propose to the Council to open negotiations on the assumption that Europe will develop a global constellation fully compatible with GPS. Europe should seek maximum involvement in the GPS modernisation programme (including the evolution of the signal structure) and the future development of a global integrity network. Equally, an agreement with the US would need to contain provisions for an appropriate joint management board responsible for co-ordination of policy and technical issues (signal structure, integrity networking, etc). The negotiation would also need to consider development

of a dispute settlement mechanism and any further requirements which may emerge from the ESA comparative study. The US has also made it clear that they could consider increasing European insight and input into the operation and management of GPS civil functions (e.g. through civilian representation at the civil GPS augmentation centres); reciprocally, equivalent treatment of the US within Galileo would be expected.

With the Russian Federation, the Commission will propose to the Council to open negotiations on an agreement with a view to developing a joint Euro-Russian Galileo. The agreement would need to reflect the gradualist approach set out in section 3.2 above. On the scenario of joint development, there would need to be provision for the creation of a joint steering committee to approve development of an appropriate signal structure and co-ordination of policy and technical issues, including co-ordinated infrastructure planning to ensure cost-effective transition and deployment of the future positioning and navigation networks. Respective rights and obligations under a joint development programme would also need to be agreed in detail, including dispute settlement procedures and authorised interlocutors[48]. Security concerns would need to be addressed.

The scope of co-operation with the Russian Federation will have important implications for other aspects of project development, notably financing and organisational structures, and negotiations will need to clarify what is realistic in good time for the necessary decisions in these areas.

8. THE WAY FORWARD : IMPLEMENTING THE STRATEGY

In line with the conclusions of the above sections, the following scheme to develop a European GNSS-2 constellation (Galileo) is recommended. It is envisaged that the EU Council of Ministers, and perhaps the European Council, will take decisions on the main issues by the end of June. The European Parliament also has a crucial role to play. Within this framework, the meeting of the ESA Council in May should provide clarification of the role ESA can play in the technical, financial and organisational development of Galileo.

The decisions should cover the whole period, including the operations phase. However, a major milestone will be reached by the end of 2000 when it will be possible to review these orientations.

- *setting the strategy in motion*

A decision is needed now that Europe will develop Galileo, in order to provide the political commitment necessary for industry to invest, to allow Europe to negotiate the parameters of the system with its international partners and to ensure that Europe is able to exert an influence in the development of this strategic market. This commitment could take the form of a European Council orientation to treat Galileo as a key TENs priority, in line with the

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[48] It will be important that Europe is fully aware of the various responsibilities of its Russian partners, including industry, the Russian Space Agency and the Ministry of Defence. The development of Internavigatsia as an industrial-financial consortium, responsible under its charter, inter alia, for developing the use of GLONASS for civil users (per decision of the Government of the Russian Federation, N° 1435 of 15 November 1997) and developing navigation systems within the framework of the European GNSS programmes, may provide helpful focus and coordination.

recommendation of the European Parliament. This political commitment will need to be translated into a number of specific decisions set out below.

The main features of the recommended Galileo are:

- it must be an open, global system, fully compatible with GPS, but independent from it, with a significant role for the Russian Federation;

- it should be based on medium Earth orbit (MEO) satellites, and would include a restricted access service. But decisions now should not restrict the scope to adapt design to technological progress;

- it should be developed as a public private partnership, with significant funding at European level (EU and ESA), and development of new revenue streams.

- *financing Galileo*

This Communication has identified the potential cost of Galileo and the options for financing it, on the basis that, with the GPS signal currently available free, significant public finance will be needed. It is not necessary or possible, now, to make final decisions on the exact split between different sources of finance, but endorsement is sought for each of the aspects of the financing approach.

First, a significant allocation of EU funding now will give the project a solid foundation. This requires a number of specific decisions:

- appropriate funding for TEN-T in Agenda 2000 on the basis of the Commission proposal and the Parliament's opinion

- adoption of the revised TEN financial regulation with provision for multi-annual programming and the possibility to go up to 20% funding for projects of European interest, such as Galileo

- Council and Parliament endorsement of the proposed allocation of €500 million for Galileo in the transport TEN multi-annual programme

- Council and Parliament recommendation to the Commission to facilitate the use of 5th Framework Programme resources of around €120 million for the Galileo development

Second, on revenue streams:

- a decision is needed on whether to pursue the option of a levy on receivers, which could make a significant contribution to financing the project.

- other revenue streams are reliant on the extent to which specialised users will pay for a better quality, guaranteed or certified service. The Commission is setting up a Special Task Force, led by the private sector, to carry out the substantial further work needed to look into this. Once revenue streams which would allow the establishment of a PPP and needs for regulatory action have been identified, the Commission could be mandated to develop appropriate proposals.

Third:

- endorsement of a PPP approach. As well as helping to improve value for money and giving users' needs a central role, this will be a clear signal that the private sector should confirm its own commitment to the project by investing risk capital in it. Setting up a PPP will require a significant amount of further work on performance requirements, risk allocation and revenue streams, which should be a priority for the definition phase.

- *managing the development of Galileo*

The definitive organisational structure does not need to be decided now. The first priority is to make clear arrangements for the definition phase (June 1999 to December 2000). This means:

- confirming that the key strategic decisions should be taken in the EU institutional framework (and not solely the first pillar), with the GNSS High Level Group to support the Commission by giving strategic orientations and accompanying the development of the Galileo programme, including the international discussions and negotiations

- putting in place a Programme Management Board, chaired by the Commission, to develop an appropriate programme management structure (involving a vehicle company), to co-ordinate research and development for Galileo, to finalise performance requirements and to establish, on the basis of private sector input, a business case for the public private partnership. This would be supported by a technical task force in the definition phase. On the basis of the work of the Project Management Board, the Commission would make recommendations to the Council and Parliament, at the end of the definition stage, allowing firm decisions on programme structure and financing

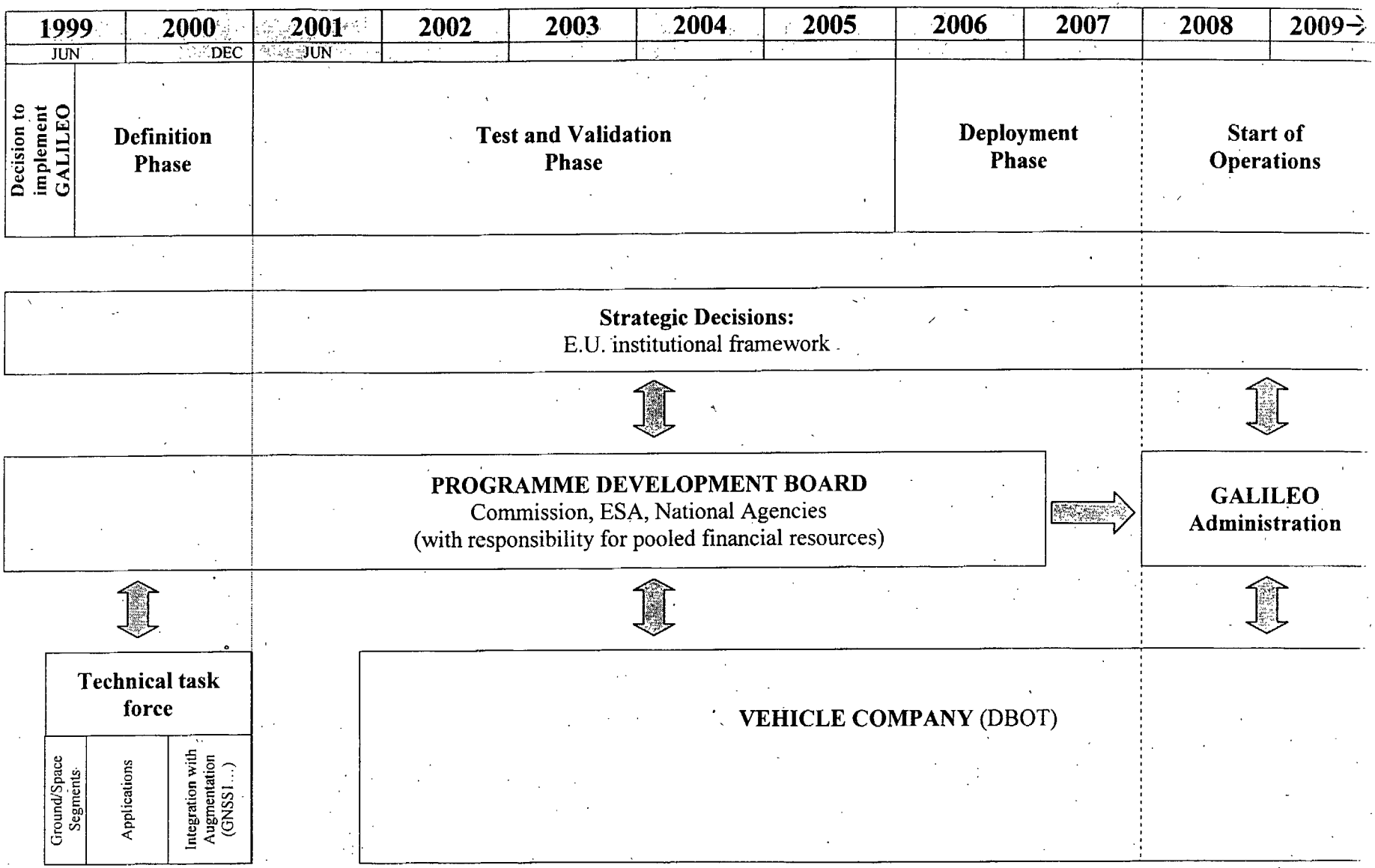
As far as the long-term organisational structure is concerned, the Commission envisages a Galileo Administration in the operations phase to manage (through the vehicle company) provision of satellite-based navigation services and guarantee these services and performance. The Commission will also need to develop further the concept of regulatory co-ordination, based on existing regulatory structures

- *establishing the international environment*

There is a need to go beyond the exploratory stage in discussions with the US and the Russian Federation. Key decisions in the definition phase depend on the nature of the commitments our partners are willing to make. The Commission intends to submit, as soon as possible, the negotiating guidelines foreshadowed in this Communication for endorsement by the Council.

Exploratory discussions with other countries will also need to take place, to assess the scope for their practical involvement in Galileo.

ANNEX 1: Evolution of organisational structure over the phases of the GALILEO project



Notes: Ideally Vehicle Company should be put in place at outset of test and validation phase. If this is not possible, thetechnical task force would have to become a Project Development Office to run the project initially.

Annex II a): Main Characteristics of Orbits Considered for Galileo

Several different scenarios could be envisaged for the Galileo space segment. The choice of orbit or the combination of orbits results from a compromise between different parameters, such as number of satellites, coverage, cost, ground segment required, etc.

LEO (Low Earth Orbit)

The LEO approach (up to 2000 km) has previously been chosen for numerous personal telecommunications constellations, including Globalstar and Iridium, as well as for the Transit system for navigation. Its main advantages come from the low cost of receivers and satellite payloads. However, the orbital period is 45-90 minutes, with each satellite in view only for a short period (approximately 15 minutes). A large number of satellites is therefore required.

MEO (Medium Earth Orbit)

The MEO approach (between 5000 and 20,000 km) was selected for GPS and GLONASS. Both operate in circular orbits around 20,000 km, leading to two complete orbits per satellite per day (orbital period of 12 hours). The launch cost is higher than for LEO satellites but the number of satellites required is lower.

GEO (Geostationary Earth Orbit)

GEOs (at 36,000 km in the Equatorial plane) have been used for telecommunications, television and the navigation satellite system augmentations being developed by the US, Europe and Japan (respectively, WAAS, EGNOS and MSAS). It involves a circular orbit of a period of 24 hours, so that they appear to be stationary over a fixed point on the Earth's surface. However, a principal disadvantage is that high latitudes are poorly covered. Further, the cost of the satellites and launches is relatively high.

IGSO (Inclined Geosynchronous Orbit)

IGSOs (which are a variation on the GEO approach, similarly at 36,000 km) follow a 24 hour circular period orbit, inclined at the Equatorial plane. This facilitates coverage of the polar regions. No IGSOs have yet been brought into commercial application. The cost of the satellites and launches is relatively high.

ANNEX II.b): ACRONYMS

Global systems	
GNSS: (Global Navigation Satellite System)	a world-wide position, velocity and time determination system which fulfils on a permanent basis potential user requirements for civil applications
• *GNSS-1*	an initial implementation of GNSS, based on GPS and GLONASS augmented by civil systems (such as EGNOS, WAAS and MSAS)
• *GNSS-2*	a second generation system which meets the requirements of civil users for position, velocity and time determination and is capable of providing a sole means of navigation for defined applications
GPS: (Global Positioning System)	satellite positioning system developed, owned and operated by the US Department of Defense
GLONASS: (Global Navigation Satellite System)	satellite positioning system developed by the USSR and now operated by the Russian Federation (currently the Ministry of Defence)
"GALILEO"	proposed European contribution to GNSS-2 based on a satellite constellation, fully interoperable with the GPS signal structure. It will be integrated with augmentations and terrestrial systems to form the trans-European positioning and navigation network.
Regional augmentations, designed to provide the user with sufficient independent monitoring of the whole system, as well as additional precision and satellite availability	
EGNOS: (European Geostationary Navigation Overlay Service)	multi-modal augmentation of GPS and GLONASS being developed by Europe. EGNOS will, as appropriate, be integrated into Galileo.
MSAS: (MTSAT[1] Satellite-based Augmentation System)	regional augmentation of GPS being developed for civil aviation by the Japanese Civil Aviation Bureau
WAAS: (Wide Area Augmentation System)	regional augmentation of GPS being developed for civil aviation by the US Federal Aviation Administration
LAAS: (Local Area Augmentation System)	local augmentation, generally required for specific applications, such as precision navigation (e.g. to support aircraft landing and ship docking) or enhancement of satellite signals where necessary because of geography (e.g. the high latitudes). These may form sub-regional networks.
Differential GNSS:	a correction of basic satellite signals (currently, GPS and GLONASS) calculated at ground stations and broadcast to provide local or wide area enhancements of services

[1] MTSAT: Multi-functional Transport Satellite

ANNEX III a): FINANCIAL STATEMENT

1. TITLE OF OPERATION

Communication from the Commission: "Galileo – involving Europe in a new generation of satellite navigation services"

2. MAIN BUDGET HEADINGS INVOLVED

B5-700 Financial support for projects of common interest in the trans-European network

B6-6 Fifth Framework Programme, Information Society Technologies (6-6121) and Sustainable and Competitive Growth (6-6131)

Other budget headings will be used as appropriate.

3. LEGAL BASIS

One or more of the following depending on the actions undertaken:

Articles 74, 84(2), 113, 129c and 130i of the Treaty.

Decision No 1692/96/EC of the European Parliament and of the Council of 23 July 1996 on Community guidelines for the development of the trans-European transport network.

Council Regulation (EC) No 2236/95 of 18 September 1995 laying down general rules for the granting of Community financial aid in the field of trans-European networks (and proposed amendment to Council Regulation 2236/95 laying down general rules for the granting of Community financial aid in the field of trans-European Networks, COM (98) 723 final, 4 December 1998).

Other relevant documents

Communication from the Commission to the Council and the European Parliament – 'Towards a Trans-European positioning and navigation network: including a European Strategy for Global Navigation Satellite Systems (GNSS)'

Council Conclusions of 17 March 1998 on a European Strategy for Global Navigation Satellite Systems (GNSS)

European Parliament report of January 1999 on a European Strategy for Global Navigation Satellite Systems (GNSS)

4. DESCRIPTION OF OPERATION

4.1. General objective

The Communication proposes a follow-up to the strategy developed in the Commission's Communication 'Towards a Trans-European positioning and navigation network: including a European Strategy for Global Navigation Satellite Systems (GNSS)' (COM (98) 29 final of 21 January 1998). It envisages development of a European satellite system (Galileo) which will contribute to the implementation of a trans-European positioning and navigation network. The objective of establishment of such a network is to improve the efficiency of transport systems by placing at the disposal of users a system allowing geographical positioning and precision timing. This contributes to development of sustainable and safe mobility for persons and goods, one of the fundamental objectives of the Common Transport Policy. The strategy also supports other Community policies such as for employment, industry, environment, cohesion and co-operation and development.

More specifically, a Galileo would provide added-value in the form of a controlled-access service, for which a high level of service would be guaranteed, making it more attractive to safety-critical and commercially-sensitive users. It will also enable PPP structures to be developed, involving considerable private investment in the development of a system required for public strategic reasons. Different possible revenue streams are identified in the Communication, some of which require regulatory action (Commission proposals to the Community institutions).

Galileo will also support the acquisition of a share of the rapidly expanding global export market for European industry.

4.2. Period covered and arrangements for renewal or extension

Full implementation of Galileo is expected over the period 2000-08. This fiche considers only EU Budget financing in the current financing period (1999 – 2006) (extension of provisions under future programmes succeeding the present TENs and 5th Framework Programmes may be envisaged)

5. CLASSIFICATION OF EXPENDITURE OR REVENUE

5.1. Non-compulsory expenditure

5.2. Differentiated appropriations

5.3. Type of revenue involved

Not applicable

6. TYPE OF EXPENDITURE

- Subsidy for joint financing with contributions from other parties (including the European Space Agency, industry, national space agencies);

- Research and Development activities (Framework Programme)

- Feasibility studies and demonstration projects (maximum Community contribution: 50%) eligible for financial aid under the TEN

- Grants or risk-capital participation for investment funds under the TEN

- TACIS support for training and the conversion of Russian industries from military to civil purposes, in line with the Galileo programme

- Interest-rate subsidies, funded on European Investment Bank loans

- Loan guarantees premium, on European Investment Fund guarantees

7. FINANCIAL IMPACT

7.1. The estimated cost of Galileo is between €1.6 – 2.2 billion. In addition, costs will arise from the provision of a controlled access service, security and safety certification (approximately €600-750 million). As far as the EU budget is concerned, these costs will be met from resources already envisaged in the existing financial programming, mainly for TENs and the Fifth Framework Programme: TENs financing is an issue for the Agenda 2000 negotiations, the Fifth Framework Programme has been agreed. The Communication sets out other potential sources of finance.

The table below shows the breakdown of expenditure on GNSS-1 and GNSS-2 to date:

(€ million)	1995	1996	1997	1998	Total	*Of which:*	
						GNSS-1	*GNSS-2*
B2-7 Transport							
Commitments	0	0.75	0.81	0.81	2.38	*2.38*	*0*
Payments	0	0.27	0.62	0.23	1.12	*1.12*	*0*
B5-700 Trans-European Networks							
Commitments	9.50	10.80	6.60	10.04	36.94	*36.55*	*0.39*
Payments	4.75	5.39	0.55	7.83	18.52	*18.52*	*0*

B6-7 Fourth Framework Programme							
Commitments	8.10	0.40	5.08	4.86	18.43	*12.45*	*5.98*
Payments	2.80	2.27	5.15	2.20	12.43	*9.95*	*2.47*
B7-8 External Aspects of Community Policies							
Commitments	0	0.23	0	0	0.23	*0.23*	*0*
Payments	0	0	0.23	0	0.23	*0.23*	*0*
TOTAL							
Commitments	17.60	12.18	12.49	15.71	57.98	*51.61*	*6.37*
Payments	7.55	7.94	6.55	10.26	32.30	*29.82*	*2.47*

The total development cost of Galileo, between now and 2008, is expected to be as follows[1]:

	€ million[2]
System Engineering and Management	142
Space Segment MEO GEO	 868 188
Ground Segment	252
Operations	135
Sub-total	**1584**
Certification	249
Security	63
Controlled Access Service	300
TOTAL	**2198**

1 A more detailed breakdown of costs is attached at Annex III b).

2 These figures are based on a constellation of 21 MEO and 3 GEO satellites. The overall development costs might be reduced through technical cooperation with the Russian Federation.

For the fixed costs, the following indicative sources of revenue at European level have been identified in the period 2000-6 only:

Sources of Finance for Fixed Costs	€ million
ESA[3]	500
EC	740
Of which:	
TEN-Transport	500
FP5 + FP6[4]	240
TOTAL	**1240**

7.2. Itemised breakdown of cost[5],

€ million (current prices)

Breakdown	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
TENs *(B5-700)*		*70*	*70*	*70*	*80*	*70*	*70*	*70*			*500*
Research *(B6-6; FP5 only)*	*30*	*30*	*30*	*30*							*120*
Total	*30*	*100*	*100*	*100*	*80*	*70*	*70*	*70*	tbd	tbd	

The annual breakdown of financing is provisional, and will depend on both the phasing of the project and the availability of funding.

8. FRAUD PREVENTION MEASURES

The fraud prevention measures contained in each of the instruments which are proposed to finance the different operations will apply. These include inspections, reporting, monitoring and evaluation under Regulation 2236/95, as amended, laying down general rules for the granting of Community financial aid in the field of trans-European networks: in particular, Articles 12(4) and (5) provide for regular on-the-spot checks by Commission staff and Articles 15(5) and (7) provide for monitoring and evaluation. Similar measures exist for the other Community financial instruments involved.

9. ELEMENTS OF COST-EFFECTIVENESS ANALYSIS

9.1. Specific and quantified objectives; target population

The development of a Galileo would require significant investment, from both the public and private sectors. However, the strategic importance of such an

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3 Subject to ESA approval procedures.

4 This assumes a continuation of funding by the Research Programme beyond 2002 which is subject to evalution of FP5

5 Figures applicable from 2000 are indicative and depend on the approval procedures of the respective instruments. The table considers only Community instruments (and not, for example, ESA funding).

infrastructure is demonstrated by the level of investment by the US and Russian governments in their systems. For example, US public investment in the current GPS is estimated to have amounted to $ 10 billion already and the annual cost of sustaining the constellation is estimated at $ 420 million.

Without Galileo, the EU would be entirely dependent on an externally controlled and managed system for safety-critical applications (aviation, maritime) without any guarantees on continuity and acceptable levels of service.

Furthermore, the investment in Galileo makes sense in economic terms. The GPS hardware market in Europe was estimated by US researchers in 1997 at $228.7 million and was anticipated to grow to $960 million in 2004. A study on behalf of the Commission estimated the cumulative GNSS goods and services market in Europe (1998-2007) to be worth €39 billion. New studies have confirmed further important benefits which would depend on having Galileo in addition to GPS, including an additional €40 billion from sales of equipment, and €40 billion from value added services over the period 2005-2023. Expected total benefits in the transport sector alone are in the region of €18 billion over the first five years of operation.

The Community strategy has the following objectives:

— improving the efficiency of the multi-modal transport system (increasing traffic capacity, reducing environmental damage caused by transport, monitoring consignments of dangerous or polluting substances, etc.) while increasing safety;

— providing added-value through a highly accurate service, with guaranteed service levels for users with safety-critical needs;

— ensuring close co-operation between Member States and institutions in order to maximise benefits and minimise costs at the Community level and to support the development of interoperability within a global system appropriate to present day and future transport needs;

— promoting European economic growth by stimulating the development of harmonised standards and the global market for value-added goods and services, with significant opportunities for European industry.

9.2. Grounds for the operation

— The Community contribution should be seen in the context of the measures to implement the guidelines for the development of the trans-European transport network, particularly the navigation and positioning network and the Common Transport Policy. Organising co-operation on the basis of a clear strategy using the resources available in Europe is the only means of ensuring a role for Europe in the development of GNSS.

— In its Communication, Towards a Trans-European Positioning and Navigation Network, (COM (98) 29 of 21 January 1998), which was endorsed by the Council in its Conclusions of 17 March 1998, the Commission set out the need for efficient and cost-effective navigation systems for civil use and compatible with military needs, high levels of safety with adequate European control for safety-dependent systems, and opportunities for European industry in the emerging satellite navigation markets.

— The Commission recommended in its Communication on Space (COM (96) 617 final of 4 December 1996) the preparation of a specific action plan to develop GNSS as a key space application for European industry.

9.3. Monitoring and evaluation of the operation

The operation must be monitored and evaluated on the basis of the following criteria:

— contribution to sustainable mobility through increase in air space and other traffic capacity,

— reduction of environmental damage caused by transport and monitoring of consignments of dangerous or polluting substances;

— improved safety, leading to a reduction in the number of accidents caused by guidance system error or failure (landing/ docking, collisions between vessels, etc.)

— rationalisation and optimisation of navigation systems, leading to a more coherent and interoperable global navigation aid structure appropriate to present day and future transport needs;

— allowing European industry to compete fairly and freely in all segments of the developing satellite navigation market, including commercial transport and other applications, development and maintenance of satellite equipment, ground stations and receivers. This will have a significant positive effect on European economic growth and employment.

The organisational structure put forward is designed to ensure the cost-effective management of the project including effective monitoring and evaluation.

10. ADMINISTRATIVE EXPENDITURE (PART A OF SECTION III OF THE GENERAL BUDGET)

The allocation of administrative resources for this action will depend on the annual Commission decision on allocation of resources, taking particular account of additional staff and resources granted by the budgetary authority. The supplementary needs cannot, in any case, prejudge the decisions that the Commission will need to take concerning:

- the request for new posts in the framework of the annual budget proposals
- the resources allocation.

10.1 Effect on the number of posts

Type of post		Staff to be assigned to managing the operation		Source		Duration
		Permanent posts	Temporary posts	Existing resources in the DG or department concerned	Additional resources	
Officials or temporary staff	A	4		2	2	3
	B	2		1	1	3
	C	2		1	1	3
Other resources						
Total		8		4	4	3

10.2. Total financial impact of human resources

	Amount (€)	Method of calculation
Officials **Temporary agents** **Other resources** (indicate budget heading)	2 520 000	8 x 3 years x 105 000
TOTAL	2.520000	

The amounts express the total cost of the additional posts over the total duration of the operation (if fixed) or for 12 months (if indefinite).

10.3. Increase in other operating expenditure as a result of the operation

Budget heading (number and title)	Amount (€)	Method of calculation
A-7010 (Missions, travels...)	105 000	30 annual missions within the Community 25 annual missions outside the Community
TOTAL	105 000	

Estimated expenditure on missions, by redeployment of existing resources: Article A-130:

4, 0

Annex III b). Galileo – detailed breakdown of costs

FIXED COSTS (Implementation)	Development	2 proto-flight EGNOS reuse	**21 MEOs 3 GEOs**	Total Implementation costs	RECURRING COSTS per year
	2000-2005		2005-2008	Σ 2000/2008	Beyond 2008
System Engineering and Management					
Total System Engineering and Management	*15*	*37*	*90*	*142*	*1.2*
Space					
-MEO					60
Payload	65	24	116	205	
Platform	83	38	158	279	
Launches		48	232	280	
Insurance		18	86	104	
GEO					10.8
Payload			-	-	
Platform	25		70	95	
Launches			67	67	
Insurance			26	26	
Total Space	*173*	*128*	*755*	*1056*	*70.8*
Ground Segment					
Mission		68	92		
MEO station		33	21		
GEO station		20	18		
Total ground segment	-	*121*	*131*	*252*	
Operations					
Total operations	-	*55*	*80*	*135*	*56*
Sub-total	188	341	1056	1585	128
Certification	34	26	189	249	5.6
Security	-	32	31	63	-
Controlled Access Service	50	50	200	300	6.4
GNSS organisational framework (annual running costs: this will initially rely on staff seconded from national administrations)	-	-	-	-	15
TOTAL	**272**	**449**	**1476**	**2197**	**155**

Figures above are based on submissions made by industry in the framework of ESA's GNSS-2 systems comparative study. These are indicative only and do not necessarily reflect the opinion of the Commission.

ANNEX IV: MARKET ANALYSIS AND ECONOMIC BENEFITS

Some of the main benefits of Galileo are political rather than economic, notably the advantage of retaining control over safety critical services. Other economic benefits, such as providing 'insurance' against future charging for GPS, are difficult to quantify. The analysis below can therefore give only a partial view, concentrating on[1]:

- How Galileo will enlarge the overall market for satellite navigation, primarily because GPS and Galileo together can provide a more accurate and reliable service ;
- How Galileo will improve prospects for European firms, because they will have a larger share of a larger market ;
- The direct and indirect benefits to users from Galileo.

No reliable figures are available on the extent to which Galileo will produce savings by replacing existing navigation aids, though this is also likely to be significant. Market forecasts over such a long period, in an area where technological change is rapid, must be treated with considerable caution, though the broad orders of magnitude indicate that the overall economic benefits are very significant. (For example, the new generation of mobile phone technology – UTMS- has the potential to combine with Galileo in some functions, and to displace it in others). A priority for the project definition phase (June 1999 to December 2000) is to take the market analysis to a stage where firm decisions can be taken on system performance, and where the private sector is willing to make financial commitments on the basis of future expected revenue.

It is important to distinguish between the benefits identified here, which relate to the socio-economic desirability of Galileo, and the issue of financial viability. Many of the benefits identified here will not result in project revenue without regulatory action. Nonetheless, the prospect of greater involvement of European industry in the applications market should increase its willingness to participate in a PPP to put Galileo in place.

The impact of Galileo on the satellite navigation market

A key measure of market growth is the penetration rate, which indicates what proportion of a category (e.g. new cars) is fitted with a navigation device. Forecasts suggest that penetration rates will rise much more rapidly, to a higher 'saturation' rate in the GPS + Galileo scenario compared to the GPS only scenario. Among the segments where the difference is particularly significant are:

- automobile navigation (reaching a maximum of 93% in 2013 compared to 90% in 2016) ;
- railways (reaching a maximum of 50% in 2019 compared to 10% in 2016);
- fleet management (reaching a maximum of 95% in 2013 compared to 90% in 2016); and
- mobile telephony (reaching a maximum of 70% in 2014 compared to 55% in 2018).

[1] Most of these figures were produced by industry in the framework of an ESA comparative study.

This difference is explained by the fact that these segments are particularly sensitive to service maintenance and accuracy in built up areas and in terrain (e.g. forested areas and deep valleys) which "traditional" GPS receivers find difficult, and where interoperable Galileo/GPS will offer an improved service.

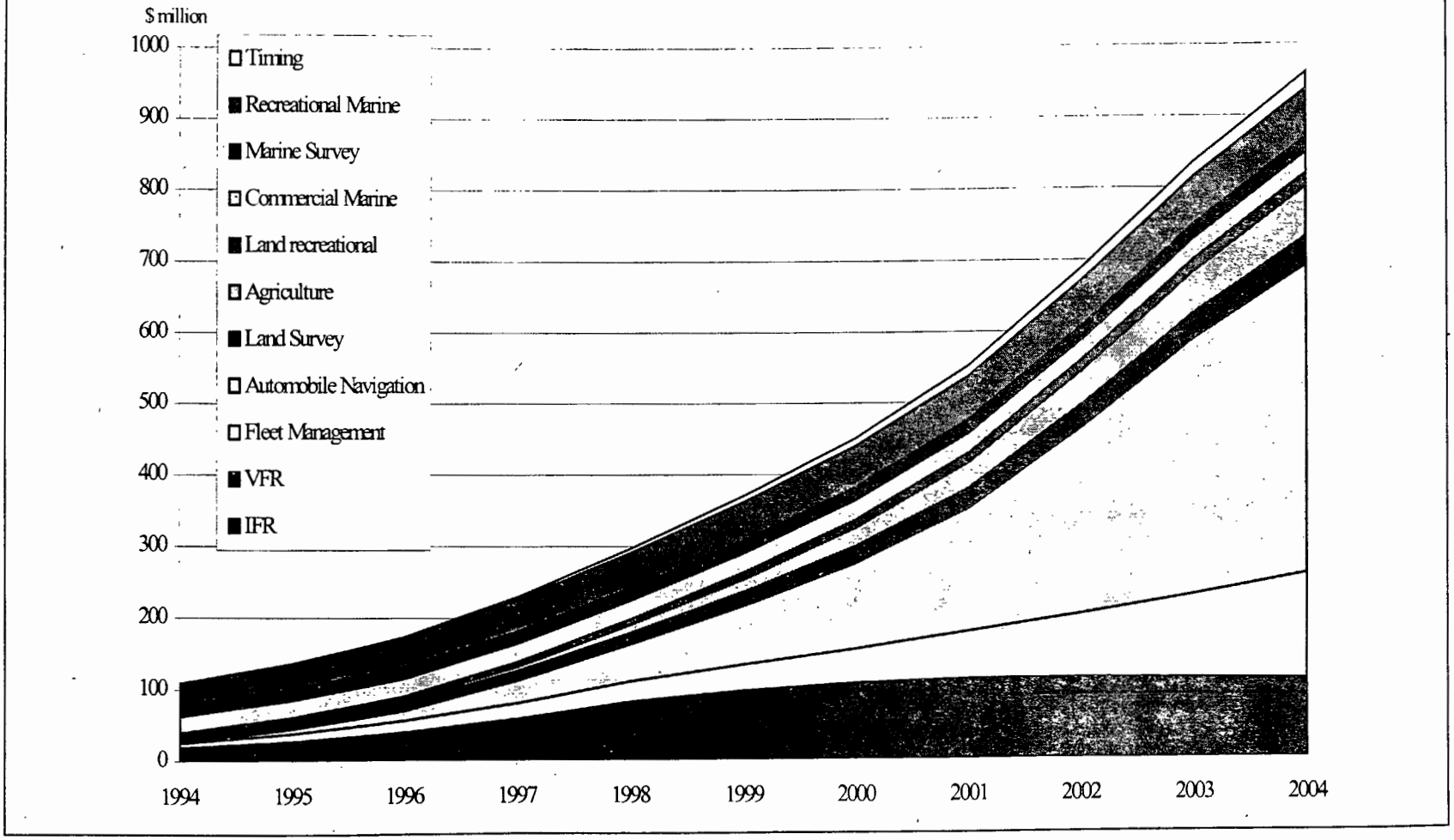
Economic benefits for Europe

The following table gives an estimate of gross economic benefits (turnover for European industry, and direct benefits for European users) from equipment sales and value-added services in the satellite navigation market, on a baseline GPS scenario, and on a GPS+Galileo scenario. It suggests that the benefits of Galileo could amount to around €80billion over the period 2005-23. These benefits arise from a combination of a larger market (as indicated above) and a bigger share for European industry. On the latter, it is assumed that the market share for EU industry under the Galileo+GPS scenario (rising from 30% in 2005 to 60% in 2023) is substantially higher than for GPS alone, (15 and 30% respectively). These figures result from research with industry, but are subject to a considerable margin of error. The figures do not take account of displacement effects.

These figures do not, however, take account of indirect benefits of Galileo, which arise for those not using the service directly (e.g. reduced congestion, environmental benefits). These can however, be expected to be significant, given that, generally, about half of all congestion costs are 'indirect'.

	2005-23		
	Value Added Services	Equipment sales	Total
GPS	€ 74 bn	€79 bn	€154bn
GPS + Galileo	€113 bn	€122 bn	€235bn
Benefits of Galileo	€39bn	€43bn	€82bn

Figure 1: The European Satellite Navigation Market (1994-2004)[1]



1 Source: Frost and Sullivan 'European Global Positioning Systems, Markets,' in the framework of ESA comparative study
VFR = Visual Flight Rules (for civil aviation). VFR systems are typically low cost, stand alone, hand-held models used in smaller and private aircraft.
IFR = Instrument Flight Rules. IFR systems are used in aircraft with full capability avionics (passenger airliners, freight carriers and business aviation).

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